

GEOLOGICAL SURVEY OF CHINA

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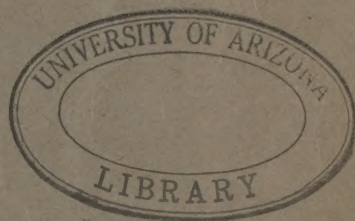
Palæontologia Sinica

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V. K. TING AND W. H. WONG

Series B. Volume 2.

Fascicle 1.



PALÆOZOIC CORALS

OF CHINA

PART I; TETRASEPTATA.

BY

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Palæontologist to the Survey and Professor of Palæontology
in the National University, Peking.

**INTRODUCTION: PETRAIDÆ, STREPTELASMAIDÆ,
AND CYATHAXONIDÆ.**

PLATE I. 74 TEXT FIGURES



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PALÆONTOLOGIA SINICA.

Editors :

V. K. Ting and W. H. Wong

Palæozoic Corals
of China
Part I. Tetraseptata

BY

AMADEUS W. GRABAU S. D.

Palæontologist to the Survey and Professor of Palæontology
in the National University, Peking.

Introduction, and Petraiidæ Streptelasmaidæ and Cyathaxonidæ.

With Plate I, and 74 Text figures



Published by the Geological Survey of China

Peking 1922.

勉遠逝而無狐疑兮
孰求美而釋汝
何所獨無芳草兮
爾懷乎故土

(原屈離騷)

Essay to journey far and do not falter

For they that seek the truth, with thee will bide.

And where the land, where good plant will not flourish?

Then why remain at home?—the world is wide.

Chu Yuan, 3rd Century B.C.



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PALÆOZOIC CORALS OF CHINA.

BY

A. W. Grabau

PART I. TETRASEPTATA.

INTRODUCTION

The corals here included in the order TETRASEPTATA, have been known by various ordinal names, among which that of *Tetracorallia* applied by Hæckel, is most frequently used. Other designations are *Zoantharia Rugosa* applied by Milne-Edwards, and *Pterocorallia* used by Frech. I have given the name *Tetraseptata** to this group in order to emphasize the tetrameral character of the septal arrangement which is fundamental in this order, and because it harmonizes with the ordinal names *Hexaseptata* applicable to those corals in which the fundamental arrangement of the septa is on the plan of six, *Octoseptata* where the number of mesenteries, and septa, when developed, is eight, and *Aseptata* where the septa are either absent, or rudimentary and in the form of spines. The *Aseptata* and *Tetraseptata* include primarily Palæozoic corals, and they appear to represent two distinct evolutionary branches, joined together by the earliest and simplest type of the aseptate group which thus is to be regarded as the more primitive of the two. The *Hexaseptata* on the other hand are derivatives of *Tetraseptata*, as is clearly shown by the primitive tetraseptate stage through which many of them pass in their earliest periods of ontogenetic development.

GENERAL TERMS.

The entire coral mass, whether simple (formed by one polyp only) or compound (formed by several or many polyps) is called a *corallum*. The individuals of a compound corallum are called *corallites*, each being built by a separate *polypite* which, however, may be laterally united to, or confluent with, its mates. The simple cup-shaped corallum is also spoken of as the *caliculum*. The area enclosed by the outer wall (*epitheca*) of a simple corallum, or an individual corallite of a compound form, is here called the *thecarium*, and within the theca various structures are developed as described below. The

* A. W. Grabau *Principles of Stratigraphy* pp. 930, 943.

upper surface, usually a more or less cup-shaped depression is the *calyx*. The details of the various structural elements of the corallum or corallite, will next be considered.

MORPHOLOGICAL CHARACTERS AND DEVELOPMENT OF THE TETRASEPTATA.

THE EPITHECA. The most fundamental structural character of the TETRASEPTATA as of the ASEPTATA, is the *epitheca* or proper outer wall which encloses the theca and within which all the other structural characters are developed. The name originated at a time when the septa were thought to be the fundamental structural characters of corals, and when this outer wall was held to be an additional covering, superadded to the so-called true wall or *theca*. This theca unites the septa in the HEXASEPTATA, where the *epitheca* is wanting or occupies only a subordinate role. Such a misconception of the relative values of the structural features of the hard parts of corals, was due to the fact that the HEXASEPTATA were made the basis of study of coral morphology, not only of the soft tissues, but of the hard parts as well. This naturally led to the coining of terms in accordance with the nature of these specialized types, and hence a derived or secondary structural feature the interseptal wall, was regarded as the true wall of the corals, and designated the *theca*, whereas the more fundamental and more primitive exoseptal wall, so prominent in the Palæozoic corals, was regarded as an additional feature, and designated the *epitheca*.

The individual development or ontogeny of a considerable number of genera of the Tetraseptata has been investigated, and from these investigations it has become evident, that the *epitheca* or outer wall is the fundamental morphological character of the hard parts of these organisms. In some cases the earliest stage of the coral is an empty caliculus or cup without septa, these appearing later. This is, however, true only of primitive types, and in the majority of cases the *thecarium*, or solid part of the caliculus enclosed by the *epitheca*, is characterized in its earliest stage by one or more cycles of septa, their appearance at so early a stage being due to acceleration in septal development.

The fact, however, that in the more primitive types, the theca is without septa in the earliest stages, unmistakably points to a derivation of the entire order of Tetraseptata from early aseptate types.

The *epitheca* has its beginning in the calcareous particles or sclerites which are separated by the cells of the basal part of the young polyp, and which unite to form the minute *basal disk* or *basal plate*. This separation of lime begins with the assumption, by the larval polyp, of a sedentary habit, and in the majority of cases the young polyp becomes cemented by this basal plate to some object of support, which may be a shell-fragment, or the *epitheca* of an older coral, or even the hardened mud of the sea-bottom.

As the polyp grows, new lime is added to the basal plate, thickening it, and at the same time increasing its size. As a rule, the principal addition, after a time, is made to the margin of the basal plate, which thus increases in area rather more than in thickness. These annular additions to the previously-formed portion, are marked externally by the *lines of growth*, which are one of the most obvious external characters of the wall or epitheca of these corals, and the one by which the epitheca itself is most readily distinguished from other structures. If the rate of addition of calcareous rings to the epitheca is commensurate with the rate of increase in diameter of the polyp, the entire caliculus will assume a flat disk-like form. This is found in certain adult corals of the Palæozoic, such as *Palæocyclus* (text figs. 1, 2) *Microcylus*, *Baryphyllum*, *Combophyllum* and *Hadrophyllum*. In the majority of Palæozoic genera however, the rate of lime deposition is more rapid than the rate of increase in diameter of the base of the polyp, and the newly formed ring of lime will, therefore, not be added to the outer edge of the preceding ring, but to its upper outer border. Thus a succession of rings of carbonate of lime is formed, one above the other, each later one having a slightly larger diameter than the one preceding it. The result of such a regular slight increase in size must inevitably be the production of a conical caliculus, and this is the usual type of form which these corals present. Even in the flat forms cited, the basal portion is not infrequently conical, the expansion into a flat caliculus being a secondary feature, and indicating a later increase in the rate of circumferential growth over the earlier part, a character the reverse of that found in most corals, where the rate of increase in diameter of the polyp diminishes proportionately in later stages.

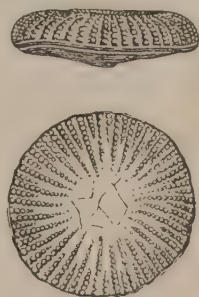


Fig. 1 & 2.

Figures 1 and 2.—*Palæocyclus*: a Silurian corallum showing expansion into a flat disk, because of uniform rate of increase in size and of lime deposition. (The young however is often conical, the flat expansion being a secondary feature) 1. side view; 2. calicinal view. (enlarged about twice).

It might be argued that the production of a flat, disk-like caliculus is the result of the development of the coral upon a hard sub-stratum, either a foreign substance, or a hard sea-bottom. There are certain modern corals, such as *Manicina*, which, when found upon a hard solid sea-bottom, show a flat base, while others, apparently of the same species, growing upon a soft bottom into which they sink to a slight degree, assume a conical form of base. This may be a direct adaptation to the environment, here expressed by the nature of the sea-bottom, or it may be the result of natural selection, those forms which have an inherent tendency to form a flat base, i.e. those in which the radial increase is balanced by the rate of lime deposition, thriving upon a hard bottom, but quickly becoming submerged in the ooze of a soft bottom if they happen to find

themselves on such an one, and never growing to maturity. Just the reverse happens to those forms in which the tendency is towards forming a conical base.

But whatever may be the true interpretation of the modern types, this theory of direct adaptation to the nature of the sea-bottom does not hold for the Palæozoic forms in question, for the flat-bottomed *Microcylus* is found in the same strata with the conical *Stereolasma*, and the form of the caliculus is in each case peculiar to the organism and not the product of adaptation.

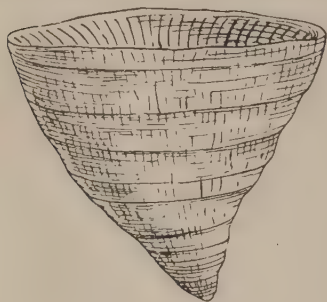


Fig. 3.

Fig. 3. A broadly conical caliculus: one, and the form of which is, in consequence, that of a long cone with relatively small apical angle (text fig. 4.) This difference in rate of expansion may not be of sufficient importance to warrant generic or even specific distinction, unless accompanied by variations in other characters. Indeed, forms otherwise alike, may vary in this respect in different localities, and this variation may be induced by different environmental conditions, such as the composition of the water, the food supply etc. which affect the physiological condition of the polyps, this effect finding expression in the relative rates of increase in diameter and of lime separation. Where such variation, however, exists in the same locality, it must be regarded as expressing a fundamental, even if slight, inherent difference in the organism, and may lead to the development of distinct genetic series.



Fig. 4.

Not all, in fact not even a majority of the Tetrastrea are characterized by a regular and uniform rate of growth which results in a uniform expansion of the caliculus. More commonly the expansion proceeds regularly up to a certain point, when it decreases in rate, or what is more usual ceases altogether. Therefore the rings of calcium carbonate which build up the epitheca, are all of the same diameter, and consequently they are added one above the other. The result is the production of a cylindrical caliculus with a conical base. (Text figs. 5 and 6). The diameter of the cylinder depends of course upon the period at which expansion ceases. Usually, where the expansion during the early stages was a rapid one, producing a low conical base, the diameter reached, when cylindrical growth commences, is large, (text

Figure 4. A narrowly conical caliculus.

fig. 5), whereas, with a slow rate of expansion, the diameter usually remains a moderate one (text fig. 6). In many Tetrastata, the period of cylindrical growth is succeeded by one of progressively diminishing diameter, the caliculus thus tapering towards the calicinal margin (text fig. 7). In other cases the contraction of the polyp is a sudden

one, and the caliculus has the appearance as if it were covered by a lid, the summit of which contains a small calyx. A diminishing diameter in all cases implies a contracting polyp, and this must generally be regarded as indicative of a period of senescence. Such a condition may, however, also be pathologic, when through some injury, or under unfavorable conditions, the polyp degenerates in size. Sometimes, after such a period of contraction, the polyp will expand again, thus producing the appearance of a succession of superposed cones. In other cases the contraction though slight, occurs at frequent intervals, followed by renewed expansion. Then a very irregular caliculus is produced (text fig. 8). Irregularity of growth is shown in most large caliculi, though in normal individuals this irregularity is not a very marked one, being indicated only by a succession of concentric growth wrinkles.

A curved form is characteristic of many simple Tetrastata, (text fig. 6, Pl. I figs, 5a, 17a, 18a) especially those of slender conical growth. Curvature of

the caliculus implies inequality in the thickness of the rings of calcareous material of which the epitheca is built, the side where the deposit is thickest becoming the convex side. Usually this is the side on which the cardinal septum is situated, but it may also be the opposite one (where the counter septum is located) or one of the alar regions. The change in direction, due to this curvature, may sometimes be 90° or more, so that the plane of the calyx comes to lie parallel to the axis of the young corallum (e.g. *Pinnatophyllum norini*, Grabau.)^{*}

Abrupt changes in the direction of growth occur as the result of accident, usually after the original fixation has been broken, and the



Fig. 5.

Figure 5. Broadly cylindrical caliculus with conical base, showing cessation of expansional growth after completion of early stages. (E & H)



Fig. 6.

Figure 6. A narrowly cylindrical caliculus, with conical base, showing cessation of expansional growth at an early stage, the rate of expansion being relatively slow.

* Described and figured in a subsequent fascicle.

coral become prostrate. The new direction of growth is not infrequently at right angles to the old (text fig. 9.)

MODE OF ATTACHMENT. In many of the corals which do not reach a large size, only the extreme initial portion is attached to foreign objects, while in other cases there may be no attachment at all, the coral remaining free throughout life. When the initial tube



Fig. 7.

Figure 7. An irregular cylindrical caliculus contracted at the calyx.

is long and slender it may be further attached by one of its sides to the object of support. Sometimes the development of a mass of epithecal tissue may result in the production of an irregular base. This may be wholly a matter of environmental influence, the same species of coral building a strong base in agitated waters, while in quiet waters little or no secondary supporting substance is added. On the other hand, such structures may be more fundamental, those individuals which possess the ability or tendency toward building a broad base, surviving in rough water, while others, not so endowed will perish, or develop only where the water is relatively quiet.

In a considerable number of corals, firm anchorage is brought about by the development of root-like proliferations from the edge of the growing cup. These proliferations will finally develop into a tube, and subsequently even become solid. Then as the corallum increases in length, they are left behind, and in the adult individual they have the appearance of basal extensions of the epitheca. They were however built from the edge of the caliculus when the individual was young.

These rootlike proliferations are characteristic of a number of different generic types, and they do not necessarily indicate relationship of the forms in which they occur. They are to be regarded rather as parallal developments, and may occur in some species of a genus and be absent in others. Thus they are found in *Amplexus spinosus*, (Plate I, figs. 22, 23) but are wanting in other species of that genus. When they are broken away, their former existence is generally indicated by a scar or a node on the surface of the epitheca. Examples of genera in which they are usually or always developed are: *Rhizophyllum* and *Omphima*, though even in



Fig. 8.

Figure 8. A caliculus showing repeated slight contractions followed by a resumption of expansional growth. (E. & H.)

these genera they may not always occur, or at any rate are developed in varying intensity.

THE EPITHECA OF COMPOUND FORMS. In compound Tetraseptata, which are generally produced by the formation of buds on the margins of the calyx of the mother corallite, the epitheca characterizes each new individual. If the corallum is a loosely growing mass, the epitheca of each corallite will show its normal characteristics, similar to those in the simple corals. The only modification that may arise, is the formation of periodic expansions or proliferations, which will bind adjoining corallites into a more resistant mass. These proliferations are always formed at the edge of the calyx, by an expansion of the polyp. Subsequent contraction of the polyp to usual dimensions, and continued lime deposition will leave the expanded part behind as a proliferation from the side of the corallite (*Eridophyllum*).



Fig. 9.

Figure 9. A slender caliculus showing abrupt change in direction of growth, the angle of change being more than 90 degrees (de Kon).

When the corallites of a compound form are closely crowded, so that the individuals assume prismatic form, the epitheca of adjoining prisms will be in close contact, and may indeed become amalgamated, though generally the corallites will separate between the epithecal layers.

At the calicinal margin, the double epithecal wall will frequently assume a zigzag form because of the alternate position of the principal septa in the adjoining calices, the wall bulging outward between the septa, that is into the adjoining corallite. (text fig. 10).

It may also happen that the epithecal wall between the corallites becomes suppressed, because the septa assume an exert growth, as a result of which the calices of adjoining corallites become confluent by their septa. This is especially marked in the Upper Devonian genus *Phillipsastæa*, which is derived from a form the walls of which are normally developed. It is however not confined to this genus, but may appear in end members of distinct genetic series. In compound forms of closely crowded corallites, the epitheca of the exposed portion of the outer members of the colony commonly unites to form a continuous *peritheca*, which envelopes the entire colony.

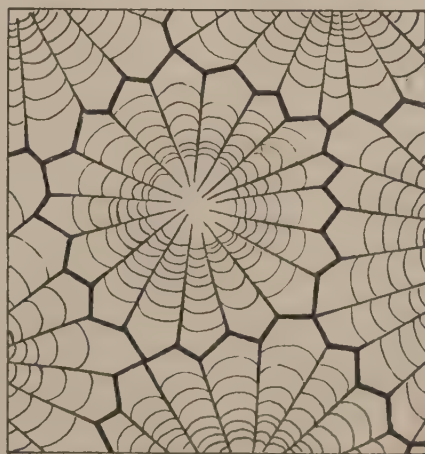


Fig. 10.

THE SEPTAL GROOVES. The epitheca of a young caliculus, or of an adult in which little subsequent

Figure 10. A group of corallites from a crowded compound corallum i.e. a coral-head showing zigzag form of epithecal wall; (*Acerularia*).

thickening occurs, shows a series of longitudinal grooves, which mark the position of the septa, each groove corresponding to the center plane of a septum. This is due to the fact that in simple corals the epitheca bulges outward between the septa, the position of the latter thus being indicated by the depression between the bulgings. These bulgings are sometimes falsely spoken of as costæ. True costæ are the extrathecal prolongations of the septa, and are formed only in the Hexaseptata and allied types (text fig. 11b, cos.) These grooves on the outside of the tetraseptate caliculus may also be spoken of as costal grooves. (Text fig. 11a, cq).

DEVELOPMENT OF THE SEPTA. In all Tetraseptata there are four primarily, a variable number of secondary, and a corresponding number of tertiary septa. In most cases the primary and secondary septa become of equal appearance in the adult, and in many descriptions they are both referred to as primary, while the tertiaries are called secondaries.

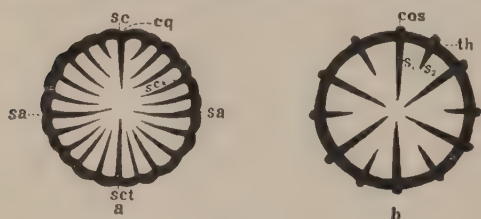


Fig. 11a-b

Figure 11a. Diagrammatic section of a tetraseptate coral, showing septa and septal grooves, (cq) the latter formed by the bulging of the wall (epitheca) between the septa. 11b. Similar section of a hexaseptate coral, showing the extension of the septa into extramural ridges or costæ (cos.)

The four primary septa consist of the *cardinal*, the *counter*, and two lateral or *alar* septa. These appear either simultaneously (in accelerated types text fig. 12) or the cardinal and counter septa appear first dividing the theca-rium by a median dorso-ventral partition into two equal lateral portions, (text fig. 13). In many primitive forms, the septa appear first as ridges on the inside of the epitheca, (text fig. 14) and by subsequent enlargement these may meet in the center. In more accelerated types, the cardinal and counter septa extend far towards the center or even meet at a very early stage. When the alar septa appear, they divide the caliculus into four quadrants, two of which are classed as cardinal, and two as counter quadrants, (text fig. 15 cq, and ctq, respectively).

In some forms the alar septa may appear equidistant from the cardinal and the counter septum, when the resulting quadrants are equal. Very often however they appear nearer to one or the other main septum, usually the cardinal one, thus leaving the counter quadrants of greater size than the cardinal. If that is the case the first of the secondary septa will appear in the counter quadrants, (text fig. 16). It is not yet positively known that the reverse obtains, though genera and species with highly accelerated cardinal quadrants (as compared with the counter quadrants) are known, and in these it might be supposed that the cardinal quadrants, when first developed, are the larger, and that the first secondary septa appear in the cardinal quadrants. This will have to be settled by a study of the young of such forms.

In the counter quadrants, the first pair of secondary septa appears next to the counter septum and each succeeding pair appears between the last-formed one, and the alar septum, in other words, in the space next to the alar septum. This is the main growing part, continuing to increase in size until it is large enough for the appearance of a new secondary septum, (text fig 17). As each new septum of the counter quadrants appears, it seems to branch off from the alar septum at a somewhat higher level when

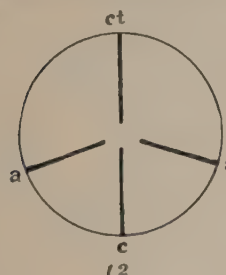


Fig. 12.

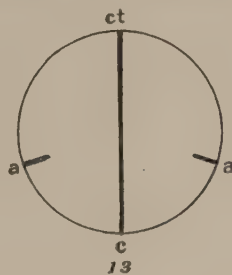


Fig. 13.



Fig. 14.

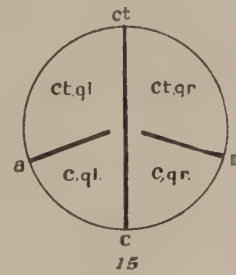


Fig. 15.

Figure 12. Diagram illustrating the simultaneous appearance of the four primary septa.

Figure 13. Diagram illustrating the earlier appearance of two of the primary septa cardinal (c) and counter (ct), followed by the alar (a).

Figure 14. Diagram of primitive coral showing the primary and second septa in the form of short ridges.

Figure 15. Diagram illustrating the four quadrants.

c - cardinal septum; ct - counter septum; a, a - alar septa;
ctql - left counter quadrant; ctqr - right counter quadrant;
cql - left cardinal quadrant; cqr - right cardinal quadrant.

viewed laterally, and the entire arrangement of the secondary septa is a pinnate one with reference to the alar septum. This is well shown in the disposition of the costal grooves on the exterior, (text fig. 19. Pl. I, figs. 2a, 14a). When the counter quadrants are highly accelerated the tertiary septa may begin to appear before all the secondary septa are formed (text figs. 18). Those next to the counter septum on either side may



Fig. 16.

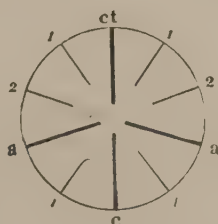


Fig. 17.

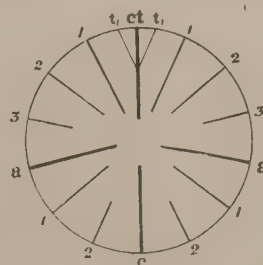


Fig. 18.

Figure 16. Diagram showing the appearance of a single pair of secondary septa (1) in the counter quadrants.

Figure 17. Diagram showing the appearance of a second pair of the secondary septa (2) in the counter quadrants simultaneously with the first pair (1) in the cardinal quadrants.

Figure 18. Diagram showing order of appearance of secondary septa; 3 pair in the counter quadrants, and 2 pair in the cardinal quadrants. A pair of tertiary septa (t) has also appeared in the counter quadrants.

c - cardinal; ct - counter; a, a - alar septa.

appear very early and assume almost the character and dignity of secondary septa. A peculiar alternation of secondary and tertiary septa is shown in *Cyathaxonia* where the corresponding tertiary septal pair appears after each secondary pair and behind it, i.e. on the counter side in the counter quadrants, and on the alar side in the cardinal quadrants. This is more fully described in the discussion of that genus.

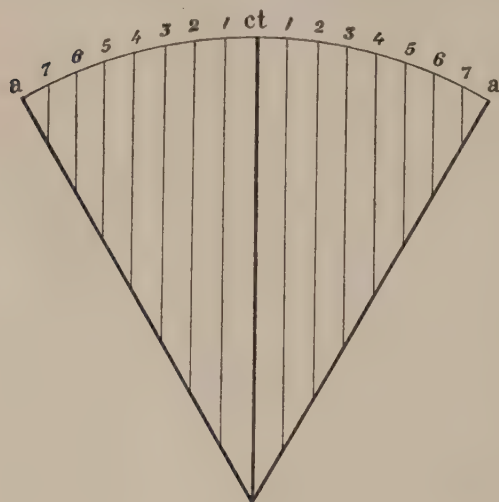


Fig. 19.

Figure 19. Diagram showing order of appearance of secondary septa (1-7) in the counter quadrants parallel to the counter septum (ct) and branching in a pinnate manner from the alar septa (a, a).

laterally, a pinnate form of arrangement of these septa with reference to the cardinal septum is produced, and this is well shown by the septal grooves of primitive species, (text fig. 20, Plate I, fig. 15a).

There are thus four principal growing points in each corallum, one on the counter side of each alar septum, and one on each side of the cardinal septum, and in these places the new secondary septa appear. The new septa are frequently joined on their inner edges with the preceding ones, and in some cases all the septa of a quadrant may be thus joined, producing a quadripartite septal grouping (text fig. 21). This emphasizes the growing areas, which then often appear as broader gaps than those between the older septa. The spaces between the latter may, moreover,

In the cardinal quadrants, the new septa appear always next to the cardinal septum where the growing end lies, that is, the increase in circumference in this part of the caliculus, takes place mainly on either side of the cardinal septum, and when the space is wide enough, a secondary septum appears in it, (text figs. 17, 18). The space between this and the alar septum increases so little as a rule, that there remains essential parallelism between the alar and secondary septa of the cardinal quadrants, and between succeeding secondary septa as well. If a slight divergence occurs, a tertiary septum will occupy the space. As each new pair of septa of the cardinal quadrants thus appears at a higher level than the preceding, when viewed

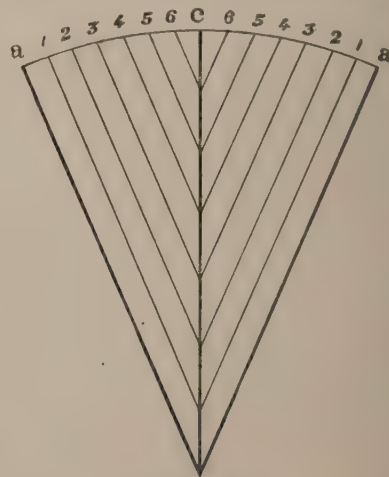


Fig. 20.

Figure 20. Diagram showing the order of appearance of the secondary septa (1-6) in the cardinal quadrants, their pinnate mode of divergence from the cardinal septum (c) and their parallelism to the alar septa 'a, a'.

be occupied by tertiary septa and by dissepiments. Such gaps are often erroneously spoken of as *lateral fossulae*. They are however, more properly called *alar pseudo-fossulae*. They occur in the young stages of the majority of the Tetraseptata, always being located on the counter side of the alar septa. They thus represent merely a stage in individual development. If they persist into the adult stage, the species must be regarded as in this respect retarded in development. (Plate I, fig. 14b).

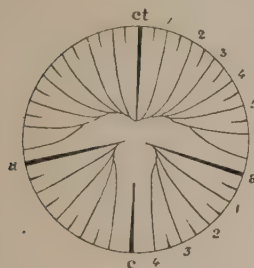


Fig. 21.

Figure 21. Diagram showing the usual arrangement of the septa in the young or primitive adult tetraseptate caliculus, the secondary septa joining the counter septum (ct) in the counter quadrants, and the alar (a,a) in the cardinal quadrants. There are seven secondary septa in each counter quadrant the youngest (no. 7) next to the alar septum where a gap, the alar pseudofossula remains on each side. In the cardinal quadrant 4 secondary septa occur, the youngest (no. 4) being next to the cardinal septum (c), on the sides of which appear the cardinal pseudofossulae which by abortion of the cardinal septum, unite to form the true fossula. Tertiary septa occur between the older secondaries.

The corresponding *cardinal pseudo-fossulae* likewise represent a normal stage in individual development, and their persistence into the adult, together with the pinnate arrangement of the adjoining secondary septa, is to be regarded as an indication of retardation in development, (*Aulacophyllum*, *Pinnatophyllum* etc.) or of long persistence of the cardinal area in a condition of growth. These two cardinal gaps often become united into a simple *true fossula*, by the partial or nearly complete abortion of the cardinal septum. (*Zaphrentis* etc.)

THE FOSSULA AND ITS SIGNIFICANCE. The true fossula is always formed by the abortion of the cardinal septum, though this may not always lie on the side of the greatest curvature. When it lies on one side, the individual is probably pathologic, while its position on the concave side may indicate racial senility. In normal individuals the cardinal septum is one of the first, if not the first to be developed, and is a prominent structure throughout the early stages of development. In a very large number of types it remains prominent throughout life, though in very old individuals, or in a few special members of a species, in which it normally is fully developed, it may become aborted

towards the last. Thus a fossula is formed only in the adult or old age of many species, or in specialized mutations of some species only. In all cases, when it occurs, it is a feature added later in the life of the individual, usually not until the adult stages. Again in some races, the early members are wholly devoid of a fossula, this appearing only in the adult of some specialized members at a late stage of their existence. Thus in the *Streptelasmaidae*, it appears first in the Devonian, and then only in specialized groups. In one family however, the *Zaphrentidae*, the fossula is a feature acquired early in the life of the group and early in the ontogeny of the individual. At any rate, it is a fully fixed character in the adults of the various generic groups of that family, though probably lacking in the young of all of them. In some of the large cylindrical forms with many

tabulæ it has become so marked a feature, that the tabulæ are affected at that point, being produced backward into a funnel-form emargination or *siphonofossula* (*Siphonophrentis*, *Siphonophyllia*). This peculiar structure leads one to think that its development is coincident with, or determined by, the concentration of certain structures or organs at the corresponding point in the fleshy polyp.

The development of the true fossula thus always indicates specialization, and it is a structure which may appear in many if not all genetic series, early in some, late in others. Therefore individuals or species with a fossula are always more specialized than related forms without a fossula, while those in which the fossula appears early, are more specialized than those in which it appears late. Nor can a form in which the fossula is feebly or not all developed in the adult, belong to the same genetic series as one in which it is strongly developed, if that species occurs at a lower geological horizon, even though we may designate it by the same generic name. It represents at the least, a retarded lateral branch.

Again it is unwise to class two species in the same genus, if one has a well developed normal fossula in the adult, while the other has such a fossula in the young stage, but develops a siphonofossula in the adult. Thus true *Caninia* never passes beyond the normal fossula in the adult, but *Siphonophyllia* passes through a *Caninia* stage, developing a siphonofossula in its own adult stage.* A young *Siphonophyllia* may therefore be mistaken for a *Caninia*, unless its immature character is recognized. Above all, the much too common practice of classing all forms with a well-developed fossula as *Zophrentis*, must be abandoned, in view of the fact that a fossula does not indicate genetic relationship, but indicates only a stage in development, in onto- or in phylogenesis, a stage reached sooner or later in practically all genetic series.

THICKENING OF SEPTA. The septa of the Tetraseptata are subject to thickening by the addition of organically deposited lime (stereoplasm). This may affect the entire septum, which then assumes a more or less wedge-shaped form, with the thin end at the center, or the thickening may proceed so far, that adjoining septa are nearly or quite in contact at their thickened ends, or for some distance of their lengths. Sometimes only the septa of one pair of quadrants are thus affected as in the case of *Pinnaphyllum norini*,** where those of the cardinal quadrants are alone thickened. This may lead to unequal subsequent erosion of the corallum, and, in the species mentioned, individuals preserving only the cardinal quadrants are sometimes found. In other cases all the septa may be equally reënforced by stereoplasm. Sometimes the thickening is confined to certain

* These genera are described in a subsequent fascicle of this volume.

** Described in a subsequent fascicle.

zones. Thus in *Pinnatophyllum* (*Heterocarinia*) *tholusitabulatum* (Yabe and Hayasaka), the thickening only begins about one third the septal length from the periphery, and dies away again towards the center. In this species too, it not infrequently happens, that the thickened portion is alone preserved, the outer zone, not thus reënforced, being worn away before the corallum becomes embedded. In that case a false impression of the character of the corallum is obtained. Sometimes the thickening is confined to a certain narrow zone near the inner ends of the septa, this zone then appearing as an inner wall (stereotheca), easily distinguished, however, from the true inner wall by the fact that the septa extend beyond this zone (see below). But the most remarkable case of thickening on record, is that found in the genus *Tachylasma* known at present only from Chinese rocks, where it is represented by three species. Here, in the more primitive forms, the alar and the first pair of secondary septa of the counter quadrants are thickened, while in the other species these and certain other pairs are thus reënforced. The result is the production of a unique and distinctive septation unlike any known in other types. (Text fig. 50, and Plate I, figs. 2b, 3a,b., 4, & 13b).

It should be recognized that thickening of the septa is confined to their older portions (i.e. those in the lower part of the caliculum) such character not appearing in the calyx, where, however, those septa which are thickened more than others may project more prominently.

The development and subsequent thickening of the septa is brought about in the following manner. In the young polyp, there is developed a series of radial folds or creases of the basal ectoderm, and there the calico-blasts or lime-secreting cells are especially active. As both sides of this fold deposit lime, the septum will come to consist of two distinct layers or plates which join in the center. This central junction is generally indicated in section by a dark line, which marks the junction of the two plates of which the septum is composed. As the septum grows by further addition of lime over its outside, this double character becomes more evident, especially if, as sometimes happens, the outer layers become silicified during fossilization, while the inner remain calcareous and are frequently dissolved away. On the exterior of the corallum the central line of the septum is general indicated by the costal groove, and between adjoining grooves the outward bulging epitheca may also become thickened by layers of stereoplasm continuous with those applied to the sides of the septum. If these layers are closely applied, a thick epithecal wall results, but they may also be loosely applied, when they have the character of dissepiments. (Text fig. 22).

MODIFICATIONS IN THE LENGTH OF THE SEPTA. If septa grow rapidly in length, they become crowded near the center, and a twisting of their inner ends may result.

When this is strongly developed, a well-marked median elevation or *streptocolumella* will result. This is well shown in the genus *Clisiophyllum* and may be partially developed in certain cyathophylloids, where it does not occur normally, indicating specialization in this direction.

The reverse of this process is seen in a shortening of the septa, which in normal forms, and in the young, meet near the center. When the septa fail to reach the center



Fig. 22.

Figure 22. Diagram of a part of a transverse section of a tetraseptate caliculus (much enlarged) showing four septa formed by addition of successive layers of stereoplasm. Some of these layers do not reach the outer region but form dissepiments.

in the adults of all but primitive forms, this condition is usually due to a failure of the ends to develop. The central non-septate area may be occupied by tabulæ, upon the surfaces of which the septa die away as low ridges. This is most typically developed in the genus *Amplexus* but is by no means confined to it. Indeed this *amplexoid* character as it is designated, may occur in all lines of development. Thus in the *Streptelasmaidæ*, it makes its first appearance in the Devonian, and this leads apparently to the true *Amplexus*, which is most typical of the Mississippian (Dinantian).

Among the *Zaphrentidæ* it is seen in *Siphonophrentis* of the Middle Devonian, and *Caninia* and *Siphonophyllia* of the Dinantian and Moscovian. In the *Cyathophyllidæ*, it is found in *Campophyllum* and some other genera. In each case it must be considered a specialization in a given direction, and its occurrence in different genera is a case of parallelism in development, and does not indicate relationship. The center of the caliculus may also become occupied by cystose structure as in the Devonian genus *Mesophyllum*. In some cases the septa become indistinct or discontinuous at the periphery, their place being taken by cystose structures. Such septa are spoken of as *recessive* (German, rückgebildet) and so far as known, this represents a secondary feature, the septa of the young reaching the periphery in a normal manner. It is seen in *Merophyllum* Grabau and in *Endophyllum* and *Spongophyllum*. Again it is seen in the specialized Dinantian and Carbonic genera *Lithostrotionella* and especially in *Lonsdaleia* which are derived from genera with normal septa.*

CARINÆ. These represent local thickenings of the septa, generally in the form of ridges more or less equally disposed upon the sides of the septum. Generally there are

* These genera are discussed in subsequent fascicles.

corresponding ridges on both sides of a septum, and if these are obliquely or vertically placed with reference to the plane of the calyx, they appear as regularly disposed cross-bars on the septa, being visible as such also in transverse section. The Devonian genus *Heliophyllum* shows these in greatest perfection (text fig. 23) for there they have become fully established, and are to be regarded as a fixed generic character. In the young *Heliophyllum* they are however, not found; they make their appearance gradually with the growth of the individual, and their number on each septum is commensurate with the age of the individual. When the development of this feature is a slow process, their appearance will begin late in life, and the adult will have comparatively few carinæ; when it is a rapid one, they will appear early in ontogeny and will be numerous in the adult. Thus their relative number in the adults is indicative of the relative acceleration in development of the corresponding individuals. It must, however, be clearly understood, that carinæ are not indicative of generic relationship any more than a fossula is. Thus the common practice of classing all forms with carinæ as *Heliophyllum*, is unwarranted, and has resulted in the placing of the original genotype of *Zaphrentis* in this genus, because it has carinæ.* Carinæ represent a stage in development, and occur in many genetic series, sometimes appearing only in the adults of a few forms, in which normally they are not developed, and then having only a varietal significance. Such is the case in *Pinnatophyllum scyphus* variety *carinata* Grabau, of the Devonian (North America). In other cases they characterize a species as in *Zaphrentis cornicula* of the Devonian, one of the few species of that genus in which they occur. Finally they may be so thoroughly established, that they become a generic character, reappearing in all the species of that particular genetic group. Such is the case in *Heliophyllum*, a derivative of *Cyathophyllum*.

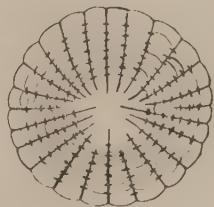


Fig. 23.

Figure. 23. Cross-section of *Heliophyllum* showing the carinæ on the septa and the dissepiments between them.

There is, however, another group of carinæ, which has a horizontal position on the sides of the septa. These carinæ may, or may not be symmetrically placed upon the sides of the septa, and become visible only in vertical or oblique sections. (*Lopholasma*, and *Lophocarinophyllum* Plate I, figs. 6-11, & 18c, text figs. 54-63). Sometimes the outer margins of these carinæ bend upwards, and then they will appear as recurving hooks on the sides of the septa in oblique sections (Plate I, fig. 9d). Transverse sections in such cases may cut the upturned edge of the carina, this then appearing as a supplementary septum, or the appearance of a double septum may be produced (Plate I, fig. 5b).

* M. O'Connell, loc. cit.

DISSEPIMENTS AND CYSTOSEPIMENTS. Dissepiments appear in section as connecting plates between the septa, and generally are trough-like structures placed obliquely with the bottom sloping inwards and the concavity towards the polyp. Typically they may be regarded as the continuation, across the intervening space, of the layers of sclerenchyma added to the sides of the septum (text fig. 22, p. 16). Towards the center they may converge into tabulæ, or they may be independent of the tabulate area if such is present. In some cases they are arranged in such a continuous series that they appear to form an inner wall bounding a central area (sclerotheca) but this is easily distinguished from the true inner wall by the fact that the septa project beyond it into the central area, which is not the case in forms with a true inner wall. *Cystosepiments* are more or less regular lines of cysts formed between the septa. They are convex towards the polyp, and mark local withdrawal of the soft tissue and the deposition of a closed cyst or vesicle of stereoplasm. When typically developed, they are readily distinguished from dissepiments, but they may grade into them.

TABULÆ. These are more or less horizontal transverse plates confined to the central portion of the corallum. They may grade laterally into dissepiments, or be distinctly bounded by an inner wall, or they may end more or less abruptly, when the periphery is formed by a cystose zone. In some cases they extend entirely across the thecarium. Their presence always indicates specialization in the normal septate caliculus. In the young individual they are, as a rule, wanting, developing only in the later stages. In primitive or unspecialized forms, they are absent, or only one or a few may develop in the adults. Thus in typical *Zaphrentis* they are wanting, or only a single tabula appears in the adult. In the more specialized *Heterophrentis*, a few tabulæ are formed, the earlier ones at considerable intervals, the later more closely crowded. In the still more specialized *Caninia* and other late Palæozoic genera, they occur abundantly. In most families they are developed in the more specialized genera. When they are very rapidly built, they may be incomplete, extending only part way across the central space and coalescing with a previously formed tabula. In certain forms they become elevated tent-like in the center (*Acrophyllum*) and this may be further complicated by a spiral twisting of the elevated portion (*Lonsdaleia* etc.) or by the formation of a solid median rod or columella (*Lithostrotion*).

CYSTOSE STRUCTURE. This is abundantly developed in many genera, occupying either a portion of the thecarium or filling it completely. In the latter case, septa may be developed only upon the surface of the cysts, the formation of the cysts preceding that of the septa (*Microplasma*) or they may form between the septa, later replacing these more or less completely (*Actinocystis*). Again they may form only in the outer zone (*Endo-*

phyllum, *Lonsdaleia*), or in the inner zone (*Mesophyllum*). Cysts are always convex towards the polyp which built them, and represent local indrawing of the fleshy portion, with the deposition of a layer of lime corresponding to the concavity produced by such a withdrawal. In the majority of cases, cysts are small and numerous, but they may locally become of considerable size. Not infrequently the outer coarse cystose zone may be more or less destroyed, together with the epitheca, in the process of fossilization, or subsequently, when the exterior of the corallum will present a very rough appearance (*Blothrophyllum*).



Fig. 24.



Fig. 25.

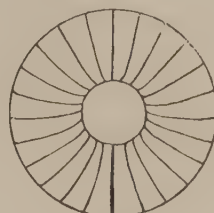


Fig. 26.

Figure 24. Section of a young stage of *Crepidophyllum*, showing the union of the septa by their inner ends into three main groups.

Figure 25. Section of an adult *Crepidophyllum* in which the alar gaps have been bridged, forming a horseshoe-shaped inner wall, open on the side of the cardinal septum.

Figure 26. Section of adult *Eridophyllum* showing complete inner wall not penetrated by the septa.

(Note: In these sections carinæ and dissepiments are omitted).

THE INNER WALL. This name has been given to various structures of diverse origin, and without genetic relationship. It will then first be necessary to define the several types thus designated, and determine their significance in terms of classification.

Mr. G. E. Andersson, while a student in my laboratory, discovered by the study of serial sections, the origin of the true inner wall of *Crepidophyllum* and *Eridophyllum*. He found that the original quadripartite arrangement of the septa persisted into the adult, but with the modification that the septa, which originally sloped towards and coalesced with the primary septa and with one another, became radial, without however losing their connection with the preceding septum. This was effected by the bending, at right angles, of the inner ends of the septa, the end of each bent portion adhering to the preceding one at the elbow (text fig. 24). Thus the ends of the septa of the counter quadrants were bent abruptly towards the counter septum from each side, those next to it uniting with it, and each succeeding septum joining the preceding one. The septa of the cardinal quadrants in like manner bend abruptly towards the alar septa joining them and one another in each quadrant. Thus an inner wall is produced with, however, three gaps in it, one at each alar pseudo-fossula, and one at the cardinal fossula. The alar gaps are bridged over by dissepiments completing the wall in this portion. In *Crepidophyllum* the cardinal gaps remain open. Thus an inner wall, with only a cardinal opening is

produced this wall sometimes assuming a horse-shoe shaped outline (text fig. 25). In *Eridophyllum* on the other hand, while the wall is of the *Crepidophyllum* type in the young, it becomes more specialized in the adult, in which the cardinal gap is also bridged over, so that it is complete throughout (text fig. 26). The result of this mode of growth is, that the primary and secondary septa, radial in the adult, join the inner wall, but do not pass beyond it, the inner zone, which is generally occupied by tabulæ, being entirely free from septa. The tertiary septa do not, as a rule, reach the inner wall. In the adult then, the perfect inner wall forms a central tube into which the septa do not penetrate. The name *phyllothea* may be applied to such a true inner wall, formed primarily by the septa themselves.

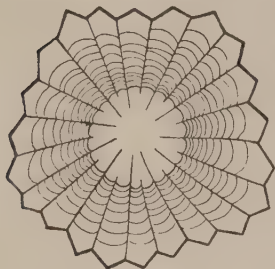


Fig. 27.

Figure 27. Cross-section of a corallite of *Acerularia* showing the crowding of dissepiments near the center to form a false inner wall (sclerotheca) with the septa extending beyond it.

A second type of inner wall may be formed by the alignment and crowding of the dissepiments between the septa at a point partway between the margin and the center. This does not form a true inner wall, though it simulates one. The principal septa (primary and secondary), however, extend beyond this circle of dissepiments towards, or to the center (text fig. 27). This type of false inner wall or *sclerotheca*, as it may be called, is homologous with the theca of the *Hexaseptata*, where the septal ends extend beyond it, i.e. outside of it, forming the costæ. It is formed by separately deposited sclerites between the septa, the latter having no part in its formation. This type of pseudotheca is found in *Diplophyllum* Hall, in *Lithostrotion* Llwyd, in *Acervularia* Schweigger, and in other genera.

A third type of false inner wall (pseudotheca) is formed by the thickening of the septa at a certain point, this corresponding in position in all the septa (text fig. 28). When the thickening proceeds so far that the thickened portions of adjoining septa touch or even coalesce, the appearance of an inner wall is produced, but this has no relationship to the true inner wall or *phyllothea* nor to the dissepimental wall or *sclerotheca*. It may be called a *stereothea*, formed by the local deposition of an excess of stereoplasm. It is found in certain American and European Devonian species of *Prismatophyllum*, and in *Phillipsastræa* from the Upper

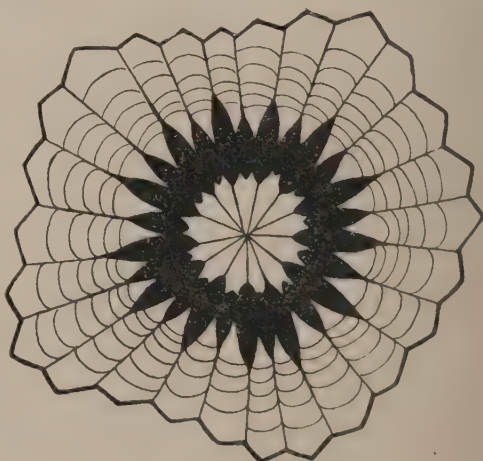


Fig. 28.

Figure 28. Section of a corallite of *Prismatophyllum* showing the formation of a false inner wall (stereothea) by local thickening of the septa.

Devonian of Europe, and especially in *Pachyphyllum*. Often the position of this type of pseudotheca corresponds to an abrupt change in the shape of the calyx from a nearly flat outer, to a steeply depressed inner area. This form of calyx also occurs in *Acervularia* where the sclerotheca of dissepiments is situated at the point of change in slope.

Finally there is a fourth type of inner wall decidedly different from those previously described. This is formed in the Devonian genus *Depasophyllum* Grabau, and



Fig. 29.

Figure 29. Diagrammatic longitudinal section of the central tabulated area of a caliculus in which the inner wall (cyathotheca) is formed by the down-bending of the margins of the tabulae.

in the Dinantian (Lower Carboniferous) species *Diphyphyllum concinnum* (text figs. 29, 30). In these forms the tabulae bend down around the edges to form a sort of shallow inverted cup, or a structure resembling the cover of a round pillbox. A series of such structures, set one above the others, forms by the vertical edges of the successive elements, a continuous inner wall, which is analogous to the true inner wall formed by the ends of the septa. The rims of these successive inverted cups are indented from without where the septa join them. Between the septa they are lobed outward, thus having a scalloped appearance. The septa thus do not penetrate into the inner margin or may extend only as short ridges on the surfaces of the tabulae. This type of wall may be mistaken for a *phyllothea* or true inner wall of the first type. It can, however, generally be distinguished from that by its scalloped or outward-lobed character between the septa.

This type of inner wall may be designated a *cyathotheca*, because it is formed by a succession of superposed shallow inverted cups. When the outer septal zone (which is often narrow) is destroyed, the wall formed by these superposed cup rims has externally the aspect of a fluted column (text fig. 30).

There are thus at least four distinct types of inner wall in the Tetraseptata. These may be summarized as follow:

1. True inner wall or *phyllothea* formed by the ends of the septa which are bent at right angles. Ex: *Crepidophyllum Eridophyllum*.
2. Dissepimental inner wall or *sclerotheca*, formed by the arrangement, in a continuous row, of one or more closely crowded series of dissepiments. Ex: *Acervularia*, *Diphyphyllum*, *Lithostrotion*.
3. Stereoplastic inner wall or *stereothea*, formed by local thickening of the septa at corresponding points, by the

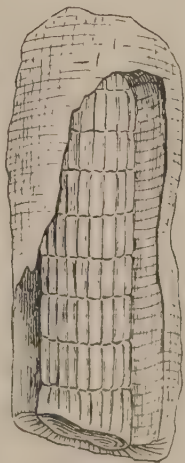


Fig. 30.

Figure 30. A part of a corallite of *Diphyphyllum concinnum* Lonsd. with the exterior partly broken away showing the inner fluted wall (cyathotheca) formed by the successive superposition of tabulae with their margins bent downwards. (After de Koninck).

deposition of stereoplasm. Ex: *Prismatophyllum*, *Phillipsastræa*, *Pachyphyllum*.

4. Tabulate inner wall or *cyathotheca*, formed by the down-bending of the margins of the tabulæ, until they join the preceding tabula. Ex: *Depasophyllum*, *Diphyphyllum*.

In No. 1 the septa do not extend into the inner zone, in 2 and 3 they normally do extend into it, while in No. 4 they do not as a rule extend into it but may in exceptional cases do so. No. 1 is a true endotheca (holendotheca) Nos. 2 to 4 are pseudothecæ (pseudendothecæ).



Fig. 31.



Fig. 32.



Fig. 33.



Fig. 34.

Figure 31-34. Diagrammatic sections of various types of corals to show the formation, by septal thickening of the pseudocolumella (stereocolumella). 31, *Cyathaxonia*; 32, *Lithostrotion*; 33, *Lophophyllum pendulum*; 34, *Lophophyllum proliferum*.

COLUMELLA AND PSEUDOCOLUMELLA. A true columella is typically known only in the *Hexaseptata*, and forms an independent elevation which begins at the bottom of the thecarium and extends to the calyx, where it generally forms a styliform projection. This is seen in greatest perfection in *Turbinolia* (Eocene) and related forms. It may be simple or complex, a solid rod or a spongy structure composed of many sclerites, and represents the deposit formed in an original indentation of the central part of the base of the polyp. In the *Tetraseptata*, the columella, is not an original but a secondary structure being absent in the young. It may be formed by a thickening of the meeting points of the septa (*stereocolumella*), either the point of junction of the cardinal and counter septa as in *Cyathaxonia* (text fig. 31) or of all the longer septa as in *Lithostrotion* (text fig. 32). Again it may be formed by the thickening of the end of the counter septum alone, as in the Dinantian species of *Lophophyllum* (text fig. 33 and Plate I, fig. 15b) or by the partial separation of the inner end of the counter septum with or without thickening (*palicolumella*) as in *Lophophyllum proliferum* (text fig. 34). These are the types commonly designated columella in the *Tetraseptata*, and they project as central round or compressed rods from the bottoms of the calices. A structure more generally designated *pseudocolumella*, may be formed by the twisting of the inner ends of the septa, and the upward projection in the calyx, of these twisted structures (*streptocolumella*) as in *Streptelasma*, and *Clisiophyllum*. Another type of pseudocolumella is formed by the

deposition in the central portion at later stages in development, of irregular sclerites (*sclerocolumella*) as in *Enterolasma* (text fig. 35) or of stereoplasm (*stereocolumella*) as in *Stereolasma* (text fig. 36) and *Lopholasma* (text fig. 52 also Plate I, fig. 5b). Again such a structure may be produced by the more conical elevation, with or without twisting, of the tabulae as in *Acrophyllum* (*acrocolumella*). This type, modified by the development of a central axis, is also found in typical *Lithostrotion*. A series of cysts may also form a more or less blister-like elevation in the center of the calyx as in some species of *Heliophyllum* and other types (*cystocolumella*). Finally there are complex types of



Fig. 35.

Figure 35. Longitudinal section of *Enterolasma strictum* (Hall) showing the *sclerocolumella* (after Simpson).



Fig. 36.

Figure 36. Longitudinal section of *Stereolasma rectum* (Hall), showing the *stereocolumella* (after Simpson).

columellas, formed by a combination of several of the structures described, as in *Lonsdaleia* and other genera. It is thus seen, that it is necessary to determine the type of columella in a given thecarium before this can be used in generic diagnosis.

FORMATION OF COMPOUND CORALLA. In the Tetraseptata, so far as known, the formation of compound coralla is due to the development of new individuals from the parent corallite, by a process of budding. This is always calicinal, that is, the new buds arise from the margin of the parent polyp, and become distinct in the calyx of the hard structure as a

marginal bud. Sometimes several or many such buds arise at the same time and their growth, together with that of the parent, may result in the formation of a compound corallum of numerous corallites in close juxtaposition. As they crowd one another, the soft-bodied polyps will assume polygonal outlines, and this will be expressed in the hard parts by the formation of closely placed calices of polygonal section. The continued growth of these polygonal individuals will result in the formation of prismatic corallites which may have their walls closely conjoined or even confluent, or the walls may remain sufficiently distinct to permit separation into individual prisms. If only a single bud forms at great intervals, this may develop into a lateral branch of the parent corallite as the latter grows in length beyond the point of formation of the bud. In that case a loosely fasciculate corallum will be produced, composed of more or less irregularly cylindrical corallites, not in contact, except now and then locally, when an epithecal connection may be effected, this strengthening the colony as a whole.

Fissiparous increase, or the development of new individuals by the division of the older, is not known to obtain in the Tetraseptata, though not uncommon in the Hexaseptata. Nor is intercalicinal budding found in the Tetraseptata, such as takes place

in some compound forms among the *Hexaseptata*, where new buds arise from the extrathecal portions of adjoining coralla (at the point of contact of the polyps). New colonies, or new individuals among the simple *Tetraseptata* are formed from ova, which develop independently of the parent.

INDIVIDUAL DEVELOPMENT OR ONTOGENY. The individual development of the coral polyp is primarily controlled by heredity, though it may be modified by the environment to a certain extent. As the polyp develops, it records its successive morphic stages in the hard parts, which therefore, properly interpreted, give a complete picture of the ontogeny. This may be deciphered by successive sections across the corallum, for as a rule the earlier stages are but slightly, if at all, modified during the succeeding periods of growth and development. As the true understanding of the genetic relationships of the corals, as of other organisms, is possible only by a study of the ontogeny of individuals, the determination of the characters of the young and immature stages in development is of primal importance. The characters of the stages can generally be readily ascertained by the study of serial sections, and this is a necessary mode of procedure to be followed in all coral study. Up to the present, only comparatively few types have been investigated in this respect, and hence much of our interpretation of genetic relationships, and indeed of generic and specific characters, based, as it is, wholly on adult characters, is inconclusive and provisional. Progress can only be made by the study of serial sections of the more distinctive species of each genus.

ACCELERATION AND RETARDATION. In the development of individuals we may observe a variable rate in the formation of new characters. In the majority of individuals of a given species it is true, the rate is a fairly constant one, especially if the individuals are obtained from a certain locality. In some, however, or in members of the specific group from another locality, the rate of development may be more rapid, so that they will acquire adult characters at an earlier stage, and may even acquire characters not found in the normal members of the species. Such individuals are called accelerated (tachygenetic), and they may constitute distinct mutations, or they may even form distinct or accelerated species. In other cases the development is slower, and the individuals are retarded (bradygenetic). They may then, in their own adult stages, not pass beyond the more youthful features of the normal forms, and so produce retarded mutations or species. Acceleration and retardation may affect the entire individual, or may obtain in certain characters only, (unequal acceleration or retardation). Indeed a form may be accelerated (as compared with the normal) in some features and retarded in others. In this manner new genetic series may arise. Thus in one case a fossula may be developed while the septal arrangement remains in the primitive tetrameral stage, and

even carinae may appear upon the septa thus retarded (*Pinnatophyllum scyphus*, and *P. scyphus* var. *carinata*). In other types from the same ancestral stock, the septa may develop beyond the tetrameral, into a radial stage, without the development of a fossula or of carinae, (*Cyathophyllum*). In still another group carinae may develop at an early stage, with radial septa, while a fossula does not develop or only in exceptional cases (*Heliophyllum*). It is thus seen that for a proper understanding of the individuals, the stage in development reached by each morphologic character must be ascertained.

Acceleration and retardation may be caused by the stimulating or retarding effect of the environment, or it may be the expression of normal inherited developmental vigor or lack of the same.

INTRACOLONIAL ACCELERATION AND RETARDATION. As colonial forms are made up of many individuals, some of which may be endowed with more or with less developmental vigor than others, it not infrequently happens that some members of the colony develop beyond the normal while others are retarded, not reaching the normal stage in development attained by the average member. Thus in *Phillipsastræa*, while the normal individuals reach a stage in which the dividing walls are suppressed, the septa becoming exert, and those of adjoining corallites becoming confluent above the wall, there are not infrequently individual members of the colony, in which the walls are still retained. Thus there appear the characters of two species, if not of two genera, in the same colony. Again some colonies, which hold ancestral relations to *Phillipsastræa*, in which normally the dividing walls are present, may show accelerated individuals in which the wall has become suppressed by exert development of the septa. Again a colony of *Lithostrotion*, in which the columella (stereocolumella) is normally developed, may show retarded individuals in which the columella has not yet appeared, and which remain therefore in the ancestral *Cyathophylloïd* stage (*vide. L. kaipingense*, Grabau).^{*} Such a colony therefore combines individuals with the characters of two genera, a perfectly normal and possible condition, and one, indeed, which is to be expected. In all such cases, as for purposes of description and designation we must employ a single specific name for a colony (though in reality it may combine several species) the specific characters must be based on the stage in development reached by the average individual. A recognition of the principle of acceleration and retardation in colonial development, and its effect upon individual members of the colony, will lead to a proper understanding of these complex forms, and an avoidance of many pit-falls.

Retardation may also be due to injury or pathologic condition of certain parts of the colony, conditions which do not affect the main portion of the colony. Thus by the

^{*} Described and figured in a subsequent fascicle.

suppression of some buds of a compact colony, the adjoining ones may develop without interference and therefore assume the normal cylindrical form, characteristic of the original parent corallite of the colony, before close crowding induces the formation of prismatic corallites. This is not uncommon in *Lithostrotion*, *Prismatophyllum*, etc., and indeed may occur in all prismatic colonies. Injury or weakening by environmental conditions may likewise produce retardation in other respects; more rarely it may act as a stimulus for over-rapid (precocious) development, the result being local acceleration.

In the succeeding discussion these principles will be applied wherever the nature of the case permits it, though in many cases only suggestions can be made regarding the relative stage in development reached by an individual, the final determination of which must await the investigation of the ontogeny of the type in question.

ORIENTATION. In the discussion of the genera and species the calices of the corals are oriented with the counter septum uppermost, and the cardinal septum below. The quadrants corresponding to the right and left hand respectively are referred to as right or left counter or cardinal quadrants, as the case may be.

SUBDIVISIONS OF THE TETRASEPTATA.

From the point of view of their development the Tetraseptata naturally fall into two great divisions or suborders, to which the names *Proteroseptata* and *Deuteroseptata* are here applied. The suborder of the *Proteroseptata* includes all those types in which septa appear before cysts or tabulæ, while the suborder of the *Deuteroseptata* includes those types in which the septa appear after the cysts or tabulæ, or sometimes do not appear at all or are only indicated by the arrangement of the cysts. *Streptelasma*, *Zaphrentis* and *Cyathophyllum* are characteristic genera of the *Proteroseptata*, while *Cystiphyllum*, *Chonophyllum* and *Strombodes* represent the *Deuteroseptata*. These suborders represent fundamental divergences in development, and can not be regarded as in any way closely related.

DESCRIPTION OF FAMILIES, GENERA AND SPECIES.

Suborder **Proteroseptata** Grabau

Better compare
the late. 2-p

Family 1. **PETRAIIDÆ** de Koninck (emend. Grabau).

This family comprises simple corals of primitive structure, usually fixed by the base. Thecarium consisting of epitheca with simple septa in the form of longitudinal ridges but without dissepiments, columella, or tabulæ. The septa do not meet in the center, the calyx reaching to the bottom of the caliculus. In specialized types the septa may extend part-way to the center. The epitheca is thin, and shows exteriorly the septal grooves, in which the quadripartite arrangement of the septa is well shown. A certain amount of thickening of both septa and wall by stereoplasm may occur. All three orders of septa occur, the primary and secondary usually attaining to the same size, while the tertiary are shorter.

The corals of this family, which at present comprise the genera *Petraia* and *Polycalia*, show in their adult stages the persistent primitive character through which the members of other families pass. They therefore present the characters demanded for ancestral forms by the majority of Proteroseptata, and it is reasonable to assume, that the earliest members of the genus *Petraia* represent the actual ancestors from which the more specialized types of the other families were derived. *Petraia* is said to range from the Ordovician to the Dinantian, but the Ordovician forms are still little known. Nevertheless it is among these that we must look for the ancestral types of the other *Proteroseptata*. The late Palæozoic species of *Petraia* can only be regarded as persistent primitive types, unless indeed some of them may prove on study of the very young stages, to be actually

degenerate forms, in which, by a process of retardation in development, the adult form remained in a very primitive stage.

No specimens of *Petraia* have so far been discovered in Chinese rocks.

The genus *Polycalia* King of the Permian (Zechstein), apparently represents a further modification of this type in which the four primary septa have developed further, until they approach the center, while the secondary septa also have developed to a moderate degree. The quadrants in this genus are equally developed, there being five secondary septa in each. Other endothecal structures are absent.

Family 2. **STREPTELASMAIDÆ** Grabau (emend.)

Primitive to moderately specialized simple Tetraseptata, with the earliest stage, in primitive genera, often in the form of a non-septate tube, formed entirely of the epitheca. Primary septa appear before the secondaries in all but the most specialized types.

In the young of primitive forms, both primary and secondary septa appear as low ridges upon the inside of the thecarium, the calyx extending to the bottom of the caliculum. In more specialized types however, the septa meet at the center at a very early stage, thus restricting the depth of the cup. The quadripartite arrangement of the septa is retained in the immature stages of all genera, as well as in the mature stages of some primitive forms (*Streptelasma drofundum*). In most types however, this primitive quadripartite condition is replaced by a radial arrangement in the adult.

Tertiary septa are developed in all but the most primitive members of the family, appearing usually in a definite order, which corresponds to that of the secondary septa. In general they remain much shorter than the secondaries. Carinæ may be developed in some specialized types, and a fossula also appears in some of the Devonian genera. Tabulæ are as a rule wanting, except in certain specialized genera, but dissepiments occur, though they are never very numerous. They are, however, absent in the more primitive members of the family. No true columella is developed but a pseudocolumella may be formed, this taking on different character in the several branches. In some of the Ordovician types it is formed by the excessive growth in length, inwards, of the septa, which in consequence are forced to twist into a more or less solid central axis. This type of columella, especially characteristic of the genus *Streptelasma*, may be called a *streptocolumella* (*streptos* to twist). In some of the Silurian genera, the columella is formed by the interlacing of irregular prolongations from the inner ends of the septa, to form an

irregular structure which resembles in some respects the convolutions of the intestine (text fig. 35 p.23). This type of pseudocolumella may be designated a *sclerocolumella* and it is typified in the Silurian genus *Enterolasma* Simpson. In Devonian genera of this family the pseudocolumella is formed by the deposition of stereoplasm at the inner ends of the longer septa which thus form a more or less solid central axis. This type is illustrated by the genus *Stereolasma* Simpson, and is designated a *stereocolumella*, (text fig 36, p.23). Finally in the Carbonic members of the family, the pseudocolumella is formed by the partial separation (in the adult) of the inner end of one of the four primary septa (typically the counter septum), this separated end being more or less thickened by secondary deposits of stereoplasm. In some forms this inner end of the counter septum may be thus thickened without actual separation from the septum (text fig. 33, p.22). This type of columella is designated a *palicolumella* and is well illustrated in *Lophophyllum proliferum* (text fig. 34, p.22). Externally the septal grooves always show the tetrameral arrangement of the septa in well-preserved specimens.

The primitive members of this family all belong to the genus *Streptelasma*, and are represented by such types as *Streptelasma profundum* of the late Middle and early Upper Ordovician of America. This species appears indeed to be the fundamental form from which the other members of the family are derived. That *Streptelasma* itself is a derivative from an early member of the *Petraiidae*, seems to be indicated by the similarity of the young *Streptelasma* of the *S. profundum* type, to adult *Petraia*, this similarity being expressed by the short ridge-like septa, the absence of all dissepimental and other endothecal structures, and the deep calyx which extends to the bottom of the caliculus. The fact that a still earlier stage in *S. profundum* shows only an empty epithelial tube without septa, indicates that its distal ancestry is from still more primitive aseptate types, from which the known *Aseptata* have also been derived.* So far as our present knowledge permits us to judge, all the other families of the *Proteroseptata* are derived either directly or indirectly from the *Streptelasmaida* with the probable exception of the *Palæocyclus* which may have originated independently from the *Petraiidae*.

The following genera are at present included in the family *Streptelasmaida*. Those so far recognized in Chinese formations are preceded by an asterisk*.

- ✓1. *Streptelasma* Hall. Ordovician
2. *Enterolasma* Simpson Silurian
3. *Helenterophyllum* Grabau Silurian
4. *Kunthia* Schlüter Devonian

* See T. C. Brown 1918, Development of some Palæozoic corals.

- * 5. *Stereolasma* Simpson Devonian
- * 6. *Lopholasma* Simpson Devonian—Carboniferous
- 7. *Ditoecholasma* Simpson Devonian
- 8. *Kionelasma* Simpson Devonian
- * 9. *Amplexus* Sowerby, Dev. to Dinantian
- * 10. *Tachylasma* Grabau Carboniferous
- 11. *Heterolasma* Grabau Dinantian-Carb.
- * 12. *Lophophyllum* Edw. & Haime Dinantian to Carbonic
- * 13. *Arachnolasma* Grabau Dinant.-Carb?

The following genera are doubtfully placed here:

- Kanophyllum* Dybowski Ord-Sil.
- Duncanella* Nicholson, Silurian
- Metriophyllum* E. & H. Devonian

Genus **STEREOLASMA** Simpson.

Text figures 36 - 49.

The genus *Stereolasma* was separated from *Streptelasma* Hall, by Simpson (1900, p.205) on the character of the pseudocolumella, which in this genus is formed by a deposit of stereoplasma about the inner ends of the septa (*stereocolumella*) (text fig. 36, p.23) whereas in *Streptelasma*, it is formed, when present at all, by the twisting of the inner ends of the septa. This deposit of stereoplasm is however not an unusual feature in Palæozoic corals, and it might be questioned if generic separation on this basis alone were warrantable. There is however another feature in this genus, the significance of which did not escape the keen powers of observation of Simpson, though he did not emphasize it as strongly as he might have done. This is the development of a fossula by the abortion of the cardinal septum, a feature which gives the coral somewhat the aspect of a *Zaphrentis*. It is indeed with the latter genus that Simpson compares this coral, giving as its chief distinction from it, the pseudocolumella.

There is, however, no direct genetic relationship between this genus and *Zaphrentis*, the two genera belonging indeed to distinct families. The development of the fossula, which gives this coral a zaphrentoid appearance, is a feature independently arrived at in the two families as previously noted. In *Zaphrentis* and its congeners, this feature is developed at a very early period, in the *Streptelasma*idæ it appear only in such specialized late Palæozoic genera as *Stereolasma* and *Lophophyllum*.

A further point of distinction between *Stereolasma* and *Zaphrentis*, is the accelerated condition of the counter quadrants in *Stereolasma*, these always having a greater number of septa than do the cardinal quadrants. In *Zaphrentis*, on the other hand, the cardinal quadrants are generally accelerated, except in the more primitive forms, in which the quadrants are equal, as they are in the primitive *Streptelasma* (*i.e.* *Streptelasma* itself). There is thus indicated a fundamental divergence in development of the two types. Absence of tabulæ can not be considered a distinctive feature, for in primitive *Zaphrentis* these are also absent.

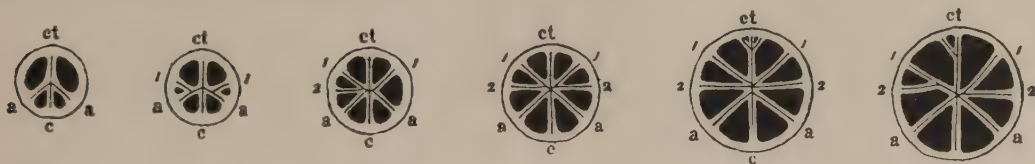


Fig. 37.

Fig. 38.

Fig. 39.

Fig. 40.

Fig. 40a.

Fig. 41.

Figures 37-41. Early stages of *Stereolasma rectum* (Hall) as shown by several sections of the same individual caliculus, except figures 37 and 40a which are from other individuals (enlarged); c - cardinal septum; ct - counter septum; a, a - alar septa; numbers indicate order of appearance of secondary septa. (After T. C. Brown).

In the earliest stages of primitive species of *Streptelasma*, such as *S. profundum* of the Ordovician, the caliculus consists merely of an epithecal tube, this being followed by the appearance of the four primary septa, and shortly thereafter, by the secondary septa in rapid succession. This is the *Petraia* stage in development (Brown 1909). It is only in the adult that the septa meet in the center while retaining the characteristic quadripartite arrangement. In *Stereolasma*, on the other hand, the initial non-septate epithecal tube is

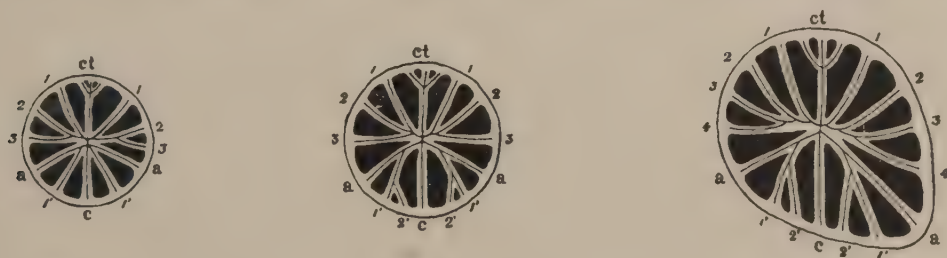


Fig. 42.

Fig. 43.

Fig. 44.

Figures 42-44. Three further stages in the development of the caliculus of *Stereolasma rectum* shown in the preceding series. Tertiary septa are well developed on either side of the counter septum (ct). (After T. C. Brown).

no longer formed, the primary septa appearing at the earliest observable stage, (text fig. 37) (Brown 1907). Thus this type is strongly accelerated in development, when compared with the primitive members of its family. The septa, throughout a considerable period of development, indeed through the neanic stage, retain the primitive quadripartite arrangement, being clustered into four groups with the alar pseudofossula well developed, (text

figs. 42-46). During this period of their development, they are therefore in the *Streptelasma profundum* stage. With the attainment of adulthood, however, the septa become radial in arrangement, except for the coalescence, in the center, of their inner ends. It is at this stage that the fossula is developed by the abortion of the cardinal septum.

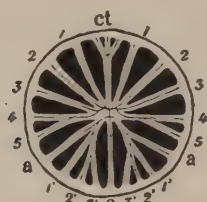


Fig. 45.

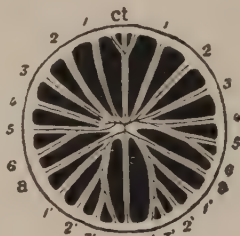


Fig. 46.

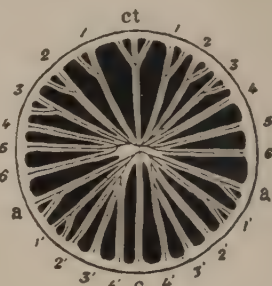


Fig. 47.

Figures 45-47. Three further sections of the caliculus of *Stereolasma rectum* showing the increase in number of secondary septa and the appearance of tertiary septa in figure 47. The accelerated condition of the counter quadrants is well shown. In figures 45 and 46 the alar and cardinal pseudofossulae are seen. (After T. C. Brown).

The dissepiments are generally few, and formed chiefly in the later stages. They are often convex inward, and then have the value of incipient tabulae or cysts. The number of dissepiments in the interseptal spaces is in most cases few, sometimes only one being present in a given section.

GENOTYPE. *S. rectum* (Hall) Middle Devonian.

***Stereolasma rectum* (Hall.)**

Plate I, figs. 1a, b. Text figures 37-49.

- 1876 *Streptelasma rectum* Hall, (in part) Illustrations of Devonian Fossils pl. 19.
- 1899 *Streptelasma rectum* Grabau, Pal. Eighteen Mile Creek. p. 127. fig. 9.
- 1900 *Stereolasma rectum* Simpson, New Genera of Paleozoic Rugose Corals. p. 205, figs. 16 & 17.
- 1907 *Streptelasma rectum* Brown, Am. Journ. Sci. Vol. XXIII, p. 277 figs. 1-13.
- 1909 *Streptelasma* (*Stereolasma*) *rectum* Grabau and Shimer, North American Index Fossils Vol. I. p. 56, Figs. 78, 79.

Corallum small, generally slightly curved, and expanding at a variable rate in the young, which gives the individual an irregular lower portion, marked by frequent constrictions which are generally restricted to a part of the circumference, though not always

to the same portion. Upper part expanding more regularly, and essentially circular in section. As only a single individual is known from Chinese rocks, this basal irregularity may not be normal. In typical individuals from the Hamilton group of New York state, the form is more regular, and the expansion more uniform, but equally irregular forms may be found. The coarsely wrinkled character of the epitheca, caused by the irregular and frequent constrictions, is also found in specimens of this species in the Traverse group (Middle Devonian) of Michigan. Between the coarser wrinkles, the epitheca shows crowded, rather regular, fine growth lines. The septal grooves are well shown, permitting ready determination of the location of the primary septa.



Fig. 48.



Fig. 49.

Figures 48-49. The submature and mature stages of *Stereolasma rectum*, with tertiary septa well developed. In figure 49 the septa are seen to have assumed a radial character, and the cardinal septum (c) has become somewhat shortened, showing the beginning of the fossula. (After T. C. Brown).

Septa more or less radially arranged in the adult. Fossula not pronounced. Septa of counter quadrants mostly reaching the center. The septa are all somewhat irregular near the center, but no twisting occurs. There is practically no deposit of stereoplasm on the septa, but the inside of the epitheca is slightly thickened by it. Dissepiments rather well developed. Tertiary septa of moderate length, longer in cardinal than in counter quadrants. Length of the specimen described about 28 mm.; diameter at calyx 19.5 mm.; at section, 16. mm.

HORIZON AND LOCALITIES. A single specimen only, has so far been obtained from the Mid-Devonian beds of Tungshan, Kütsing district, Yunnan, where it was collected by Dr. V. K. Ting. The specimen is overgrown by a species of *Hederella*. In the State of New York (U. S. A.) this species is probably the most abundant and most characteristic coral in the Middle Devonian Hamilton shales. In aspect the Chinese specimen is quite similar to many individuals from New York State though the dissepiments are more abundant than usual. The species has also been obtained from the upper Hamilton

(upper Traverse) beds of Michigan, occurring both on the east, at Alpena, and the west near Petoskey. It has also been reported from the Cedar Valley limestone of Iowa and the Devonian beds of the Mackenzie River, ten miles below the mouth of Bear River. This clearly indicates that the path of migration of this organism, between eastern North America (New York) and China, was by way of the north-west channel or Dakota Sea, and the Alaskan region* to northwestern Asia. But the path of migration thence to southern China is not yet apparent, since no Devonian formations are known from northern China. The species is wholly unknown in Europe.

It is most likely, that this species originated in the New York basin from some earlier Devonian or late Silurian ancestor, though this type is as yet unknown. The great abundance of the species in eastern North America suggest that this was the center of distribution. It is a remarkable fact that the Chinese form is so little modified that it can hardly be regarded as a variety of the typical form of the species.**

Genus **TACHYLASMA** Grabau (gen. nov.)

Corallum streptelasmoid, regularly expanding, or with slight constrictions at intervals; epitheca thin with septal grooves well marked, and showing the tetrameral arrangement. Septa subradial, all more or less thickened by stereoplastic deposits for the greater part of their length. The alar septa and the first pair of secondary septa on either side of the counter septum most prominent. Cardinal septum more or less aborted to form a fossula. Dissepimental tissue not well developed.

The essential characters of this genus are its streptelasmoid form and the strong development, by stereoplastic thickening, of four of the septa. These are the two alar, and the first pair of secondary septa in the counter quadrants, the counter septum itself being less prominent. Other septa are also thickened in some species. This indicates extreme acceleration in certain directions, *i.e.* in the septal development, and this is expressed in the generic name.

That this type is a derivative from the more specialized streptelasmoids, possibly from *Stereolasma*, is suggested by its general form and structure, and by the septal development. In *Stereolasma* the first pair of secondary septa appears in the counter

Fig. 1292 * See the Palaeogeographic Map of Hamilton time in A. W. Grabau, Textbook of Geology, Vol. II, p. 407

** The collection of which this specimen was a part had been sent to the United States for identification and has just been returned. It is barely possible, though highly improbable, that the coral described above, is an American form which has inadvertently been included in the collection. If so it is the only American form thus included. Further collecting in the Chinese rocks will have to settle this point. Dr. Ting identified the specimen as one collected by him.

quadrants shortly after the appearance of the four primary septa (See text figs. 38 *et seq.* p. 31). In another member of the Streptelasmaidae, the genus *Lophophyllum*, this first pair of secondary septa of the counter quadrants appears so early (by acceleration) that, as shown by Duerden, it is already present in the earliest obtainable sections. The present genus shows further acceleration in the thickening of these two secondary septa beyond that which occurs in the counter septum. In this respect therefore the counter septum is retarded.

Unfortunately we have not enough material to permit the making of serial sections from which the progress of septal development might be ascertained, but there seems no reason to suppose that it was other than that known in *Stereolasma rectum*.

GENOTYPE. *Tachylasma cha* Grabau, Carbonic.

This genus differs from *Pentaphyllum* de Koninck, primarily in the septal development. In that genus there are five pronounced septa, the counter septum and the two alar septa, and in addition two septa bordering the cardinal region. Sometimes the cardinal septum too is strongly developed, at other times it is aborted to form a fossula. In that genus too, the quadrants are equally developed, or the cardinal quadrants are slightly accelerated, as shown by an excess of secondary septa, as well as the strong development of the cardino-lateral septa. This allies that genus with the Zaphrentidae in which family de Koninck placed it.

Tachylasma cha Grabau (sp. nov.)

Plate I, Figs. 2a, b. Text fig. 50.

Corallum attached basally, and closely resembling *Stereolasma rectum* for which it might be mistaken from external appearance alone. Moderately curved, more so in the young than in the adult, with the counter septum on the side of greatest curvature. The corallum expands at a rather regular rate, though there are a number of irregular but not very pronounced constrictions which give the surface a moderate rugosity. Epitheca thin, the septal grooves and interseptal ridges pronounced as in *Streptelasma*, the quadripartite arrangement being well shown. Growth-lines not prominent, except at irregular intervals. Septal arrangement distinctly quadripartite, the counter quadrants being the most accelerated. Counter septum reaching to within a short distance of the center, moderately thickened by deposits of stereoplasm on each side, the greatest thickening being in the inner third of its length. It is flanked on either side by a very short tertiary septum

radially disposed. Beyond this on either side are the secondary septa of the first pair. These are radially disposed, longer than the counter septum, and much more strongly thickened than it. Their section resembles a willow leaf, with the original septum forming the mid-rib. Where the diameter of the calyx is 13.5 mm., the greatest thickness of the septum is 1 mm, while that of the counter septum is only about 0.5 mm. The next septum of this quadrant (the second secondary) is much shorter, the third is



Fig. 50.

Figure 50. Semidiagrammatic section of *Tachylasma cha* Grabau near the calyx, showing the thickened alar septa (a,a) and first pair of secondaries in the counter quadrants; the nature and relative lengths of the other septa and the formation of the fossula by abortion of the cardinal septum (c).

still shorter, being about half as long as the first, while the fourth is longer than the second but does not attain the length of the first. The relative lengths of the first four septa of this quadrant are as 5, 3, 2.5, 4. The fifth and sixth secondary septa are nearly as long as the fourth, each being a trifle less than the preceding, while the seventh and eighth are much shorter, the seventh being about half, and the eighth about one fourth as long, as the fourth secondary septum. Between all the secondary septa are very short tertiary septa, such an one also occurring between the last of the secondary (8th) and the alar septum. All the later secondary septa bend slightly towards the first one, and they are moderately thickened by stereoplasm. The alar septa are prominent, in length and thickness resembling the first pair of secondary septa of the counter quadrants, one indeed being even more thickened than these (nearly 1.5 mm).

The first three pair of secondary septa in the cardinal quadrants are of moderate strength the first two averaging about two thirds the length of the alar, and moderately thickened, while the third is longer than the preceding and more strongly thickened. All are separated by short tertiary septa. The third septum bends towards the cardinal septum, nearly embracing the area in which this is situated (fossular area). There are, however, two shorter secondary septa within this area on each side of the cardinal septum. The latter is aborted to form the fossula. (Text fig. 50).

There are then, five secondary septa in each cardinal quadrant and 8 in each counter, showing the extreme tachygenetic character of the counter quadrants, this being also expressed by the strong development of their first pair of secondary septa.

Dissepiments are very sparingly developed, and the epitheca is only moderately thickened by stereoplasm. The central area appears to be free from endothecal tissue, none of the septa reaching it. In this respect the corallum appears to be somewhat retarded.

The most striking feature of the coral is the septal arrangement and especially the four strong septa (two alar and first pair of counter secondaries). They apparently project above the others in the calyx being exert, though, because of the crushed character of the calyx in the only known specimen, this could not be ascertained with certainty. Their appearance in section resembles rather closely the Chinese ideograph for fork which is *Ch'a* (叉) (pronounced *Cha*), and this has suggested the specific name.

Length of the holotype exclusive of calicinal portion, 19 mm.; original length about 22 mm. Diameter of calyx about 16 mm., at section 13.5 mm.

HORIZON AND LOCALITY. The holotype and only known specimen was associated in the collection with two specimens of *Lophophyllum* and has moreover attached to its base two slender spines of a *Productus*. Thus its Carbonic age seems to be established. Unfortunately in the transit of these specimens to America, their travels in that country, and their final return to China, the label was lost, and the locality is therefore unknown. There is reason for believing however, that the specimen came from South China, possibly from Yunnan.

Tachylasma elongata Grabau (sp. nov.)

Plate I, figs. 13 a-c.

Corallum curved in the lower part, moderately expanding, becoming turbinate cylindrical in the adult, and contracting slightly in the final portion. Surface characterized by rather strong and numerous concentric wrinkles, and by well-marked septal grooves and interseptal ridges. In the holotype, the cardinal septum is not on the side of greatest curvature, one of the alar septa very nearly occupying this position.

At the section across the lower end, where the diameter is 6 mm. (pl. I, fig. 13c) the alar septa are most strongly developed, the first pair of counter secondaries coming next. These four septa are much thicker and longer than the others, but do not reach the center. The counter septum is slender and only about two-thirds as long as the first pair of secondaries adjoining it. There are four additional secondaries in each counter quadrant those on the left (right in figure) being best shown. Thus there are five secondary septa in each counter quadrant at this stage, the first very strong and large, the second less than half its length, the third and fourth each somewhat longer than the preceding but not reaching the length of the first; and the fifth again short.

The cardinal septum is about half as long as the alar and there are three secondary septa of similar length on either side, those nearest the alar septa being shortest. Tertiary septa are faintly developed at this stage, but no dissepiments occur.

At the other end of the fragment, which is 35 mm. long, the section, which here is only a short distance below the calyx, has the appearance shown in fig. 13b. plate I. The alar septa are strongly thickened and club-shaped, while the first pair of counter secondaries is similar, but the thickening less in amount. They are also of unequal length. The counter septum between them is narrow, slender and about half the length of the longer secondaries. There are six additional secondaries in each counter quadrant. The second is less than half the length of the first, the third and fourth are progressively longer, and the last three again somewhat shorter and slightly unequal.

The cardinal septum is short, producing a marked fossula. The three secondaries adjoining it (2 to 4th) are strong and approximately equal, while the one next to the alar is much shorter.

There are thus four secondaries in the cardinal and seven in the counter quadrants. Tertiary septa are developed as mere spinous projections, and dissepiments are absent.

This species is thus somewhat less advanced in septal development than is *Tachylasma cha*, but the length of the corallum is nearly three times that of the preceding species though its calicinal diameter is about the same.

HORIZON AND LOCALITY. In the Lower (?) Carboniferous limestone of Fengchen in Kiangsi province. One specimen.

Tachylasma aster Grabau (sp. nov.)

Plate I, Figs. 3a, b, 4. Text fig 51.

Corallum more slender than that of *Tachylasma cha*, tapering at a much less rapid angle but shorter than *Tachylasma elongata*. Calyx unknown, but principal thickened septa probably more or less exert.

The largest section obtained is circular, with a diameter of 12 mm. The counter, alar, and several of the secondary septa are thickened inwards until they have a club-shaped section. These thickened septa meet in the center and join into a larger stereoplastic body, from which the tapering ends of the septa radiate like rays from the central part of a star. On the cardinal side this central mass is marked by a long narrow

slit which reaches beyond the center and is bottle-shaped in section with a narrow neck. Through this neck a slender thread-like prolongation of the cardinal septum enters the flask-shaped slit. The outer half of the cardinal septum is thicker, but it is still the thinnest of all the septa.

The alar septa are the most strongly thickened, the first pair of secondaries in the counter quadrants coming next, though the counter septum is almost as much thickened as they are. As will be seen later this is not the case at an earlier stage. In the left counter quadrant, the third fourth fifth and sixth secondary septa are only slightly less thickened, forming a part of the central asteroid column. The second and seventh are shorter and do not joint the central column. In the right counter quadrant, only the fourth and fifth secondary septa are sufficiently thickened and lengthened to form a part of the central mass, but the third and sixth are not far behind in this respect.

The second and third secondary septa of the cardinal quadrants are also thickened, and join the central mass, while the first and fourth are shorter and free.

Short tertiary septa occur in all the interspaces. In some cases these are joined at their inner ends to the secondaries. On either side of the cardinal septum occurs a tertiary one which curves towards it. A few dissepiments occur between the secondary septa.

A section of this same individual, four millimeters farther down, on the other side of the rock slice, is shown in fig. 3b Pl. I, (reversed). It is 9.5 mm. in diameter, giving a rate of tapering of 1 in 1.6 mm. The alar and the two principal secondaries of the counter quadrants are the strongest of the septa. The counter septum is much weaker, but its thickened end fills the space between the other two. In the left counter quadrant (right in figure) the third fourth and fifth secondary septa join the central body; they are however less thickened than the first. The sixth, which in the section four millimeters higher, also joins the central body, is here free, though thickened, and tied to the alar septum by a dissepiment. The seventh, well developed in the higher section, has not yet appeared. On the right (left in figure) the second and third septa of the counter quadrants are free, the fourth and fifth joined to the median body, while the sixth is short and free. The seventh, also well developed in the higher section, has not yet appeared.

The cardinal quadrants have their septa only slightly less developed than in the higher section. The first in each case is free. The second and third on the left (right in the figure) join the central mass, on the right (left in view), they are still, in part at least, distinct, though joined together and meeting the counter septum. The fourth on each side is shorter and bends to the cardinal which is long but slender, becoming more

attenuated towards the center where it meets the central mass. The tertiary septa are for the most part still buried in the stereoplasmic thickening, especially in the cardinal quadrants. In the counter quadrants they become free.

A section about 2 mm. lower (diameter 8 mm.) shows a nearly complete filling in of the endothecal area by stereoplasm, only a few loculi remaining near the periphery.

An earlier stage of another individual from the same rock as the preceding, (Pl. I, fig. 4), also shows a subcircular section about 8.5 mm in diameter. The alar septa, and the first septum of each counter quadrant, are thickened to club-shaped form, meeting and joining in the center of the corallum by their thickened ends. The counter septum is also thickened but less so than the others, with which it becomes confluent at the thickened end. Two other septa *i.e.* the fourth septum in each counter quadrant, are long and somewhat thickened uniformly, meeting the others at their inner ends. The second and third are shorter and radially disposed, those of the right quadrant being longer than those of the left. In the right counter quadrant, septa 5, 6, & 7 are radial, stop short of the center, and decrease in size progressively towards the alar septum. On the left, the corresponding septa are much shorter, the 7th being hardly separated from the alar septum close to which it lies.

The cardinal septum is thin and long, slightly curved, and enters the triangular central space between the thickened ends of the alar septa. There are four radially disposed septa in each quadrant, two central ones long, their relative proportion different in the two quadrants, and two short, one on either side of the longer ones. Heavy dissepiments unite some of the septa at or near their inner ends.

The epitheca is greatly thickened on the inside by stereoplasm, the innermost layer of which is continuous with that of the septa. Within this thickened wall of stereoplasm, which is in this section a millimeter or more in thickness, are seen short tertiary septa which do not enter the interseptal cavities. Septal grooves very slightly developed.

The stage here described approaches closely the adult stage of *Tachylasma cha*, but is still more accelerated than that, although the section is that of a much younger individual.

A section about 4 mm. lower down, (diameter 6 mm.) shows solid filling of stereoplasm between the septa, except on either side of the cardinal septum, where slight lacunæ remain. The alar and first counter secondaries unite on either side, completely cutting off the septa between them from the rest of the corallum. In this area are four or

five shorter septa. The counter septum is long, extending to the center, and the same is true of the cardinal septum. Individual thickening of septa is not apparent, but the filling between them is rather uniform.

A section about 2 mm. lower, (diameter 4mm. text fig. 51) shows the four primary and the first pair of counter secondaries meeting in the center. The alar are the strongest while the others are about alike and somewhat less strongly developed. Three additional shorter septa occur in each counter quadrant making four in all, while only two occur in the cardinal quadrants. The interspaces are filled with lime carbonate.

HORIZON AND LOCALITY: This species was obtained by Messrs. C. C. Liu and C. Chao from dark limestones in the coal series of Changhsing Coal Mine, province of Chekiang. Two individuals are associated in the same rock fragment. The age of these beds is probably Permian.

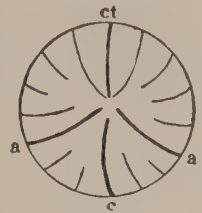


Fig. 51

Figure 51. *Tachylasma aster* Grabau. Arrangement of the septa in the early portion of a caliculus. (Enlarged).

Genus **HETERELASMA** Grabau (gen. nov.)

Plate I, figs. 14a, b.

(Genotype: *Hadrophyllum edwardsianum* de Koninck, Nouvelle recherches, 1872, p. 52, pl. IV, figs. 2, 2a.)

Corallum small, simple, gradually expanding, the basal portion moderately curved. Epitheca thin with the septal grooves well marked, showing the primitive pinnate arrangement, with the cardinal groove on the convex side. Calyx deep, with the septa in the primitive grouping in four series, their inner ends uniting, and still exhibiting the four pseudo-fossulae, one on either side of the cardinal septum, which is fully developed, and one next to each alar septum. In this respect then the coral has the characters of *Streptelasma profundum*, and as it is a late Palæozoic type, this persistence of primitive ancestral characters indicates retardation in development. In two other respects, however, the coral is more specialized, or accelerated. In the first place the counter quadrants are accelerated as in all but the primitive *Streptelaspaidæ*. While the number of secondary septa in the cardinal quadrants is from 5 to 6, that in the counter quadrants is from 7 to 10. In the second place acceleration is shown by the partial abortion of the counter septum, thus producing a true counter fossula, a feature not found in any other

member of the family *Streptelasmaida*, and representing a degree of acceleration beyond that usually found in these corals.

The genotype *Heterelasma edwardsianum* (de Koninck) Grabau, the only species so far known, occurs in the Carboniferous limestone (Dinantian) of Tournai, Belgium.

Genus **LOPHOLASMA** Simpson.

(Bull N. Y. State Mus No. 39, 1900, p. 206).

Text figs. 52, 53.

This genus was created by Simpson for a Devonian species (*S. carinatum* Simpson) which in its external characters resembles closely the common *Stereolasma rectum* of the Hamilton group of western New York, (U. S. A.) with which it is associated. The corallum is conical, straight or slightly curved; the epitheca is marked by wrinkles of growth and numerous growth-lines, but shows distinctly the septal grooves. Septa alternating in size, the larger extending to the center, where there is a deposit of stereoplasm forming a pseudocolumella (stereocolumella), which does not rise above the bottom of the calyx. Sides of septa characterized by strong, essentially horizontal carinae which extend from the exterior wall to the extremity of the septum (See text fig. 52). In transverse section, curved, spur-like processes are seen proceeding from the sides of the septa. Tabulae, if present, delicate; dissepiments frequent.

Simpson states that the nature of the spur-like spines has not been ascertained. They appear to be common features in the Carbonic *Streptelasmaida* of China for they occur in several species of *Lophophyllum* as well as in this genus. They have the appearance of cross-sections of branch septa, growing out from the main septum and not infrequently they are found to extend continuously to the margin if they begin as outward pointing spines, or they extend to the center as supplementary septa if pointing inward at the beginning. It is however still uncertain whether these spines are really always sections of plate-like branches of the septa. As shown by sections of *Lophophyllum acanthiseptum* Grabau (*postea*) similar spine-like processes occur where the carinae are cut obliquely. Again where an upturned edge of the carina is cut by the section, the appearance of a branch septum is produced. A series of sections of calicula of the type species, *L. carinatum*, or an unusually well-preserved individual, is needed, to fully solve this problem. The species described below carries this genus into the Carbonic. The Devonian form is probably derived from *Stereolasma rectum*.

KNOWN RANGE: Devonian to Lower Carboniferous.

Lopholasma carbonaria Grabau (sp. nov.)

Plate I, Figs. 5a, b; 7d, 8d, 9d, 10d, 11d, and 12. Text figures 51-56.

Corallum small and generally more gently tapering than in *L. carinatum*. The specimen fig. 5, has a length of 23 mm. and its diameter is 9.5 mm. Apical portion bent nearly at right angles but the greater part of the caliculus straight, or else the whole corallum irregularly curved. Epitheca thin, with frequent not very pronounced growth wrinkles and faint growth-lines. Setal grooves marked, especially in the young, more or less obscure in the adult; inter-septal ridges somewhat angulated along the center. Section circular. There are slight, irregularly disposed, nodes, suggestive of the bases of rhizoid proliferations. Septa radial, except those on either side of the fossula, which converge slightly at their inner ends. Fossula narrow, with the cardinal septum very short. There are about 10 septa on each side of the median axis, many of them appearing double where the section cuts the margins of the carinæ (Plate I, fig. 5b). In a few cases they even appear to be triple. In a number of cases, spine-like processes project from the central area about half-way towards the periphery. All of these appearances are probably due to the fact, that the upturned margins of the carinæ have been sectioned. The central portion of the corallum is occupied by a mass of stereoplasm which connects the inner ends of the septa, and occupies about two fifths of the endothecal area. It forms an irregular pseudocolumella. The outer wall is also strongly thickened by stereoplasm, but the septa only slightly so. Their chief modification lies in the development of the septal carinæ, which are more or less horizontally disposed. These carinæ have their outer margins upturned, and when a section is nearly parallel to the carina, this sectioned upturned margin appears like a delicate branch septum. When the section is oblique to the carina, the appearance of a spine is produced, the length of which is proportional to the nearness of the section to parallelism with the carina. Dissepiments are fairly numerous, thin and for the most part cystiform, *i.e.* convex inwards.



Fig. 52.

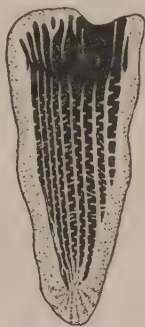


Fig. 53.

Figures 52-53. *Lopholasma carinatum* Simpson. Middle Devonian, New York (U. S. A.) (After Simpson enlarged).

52. Longitudinal section showing depth of calyx, pseudocolumella, and the edges of horizontal septal carinæ. (compare text figure 65).

53. Longitudinal section near the margin, showing the edges of the septa and the width of the carinæ (compare Plate I, fig. 18c).

A series of sections of a typical individual from Shantung, embedded in rock, shows the gradual modifications during the progress of development. (Plate I, figs. 7-11 specimen *d*; the sections are cut obliquely). The cardinal septum is less thickened by

stereoplasm than the others. In a section 6 mm. in minimum diameter* (Pl. I, fig. 8d, text fig. 54) the septa are all united by stereoplasm, and much thickened. Some of the septa divide near the periphery or have slender septa joining them, this appearance being due to the carinae. Between the septa are cystose dissepiments, *i.e.* with their convexity inward, these probably being also in many cases sections of carinae. Spines are shown on the opposite side of the same rock slice (Pl. I, fig. 9d, text fig. 55) which is 3 mm. thick. Here



Fig. 54.



Fig. 55.



Fig. 56.

Figures 54-56. *Lopholasma carbonaria* Grabau. Three successive sections (somewhat oblique) of the specimen shown in Plate I, figs. 8d, 9d, and 10d respectively, enlarged. (Figs. 54, and 56 are reversed, 55 in normal orientation).

the minimum diameter is 8 mm. The dissepiments have practically disappeared, having been broken up into the spines, which appear to be the remnants thereof. The cardinal septum is thin but still reaches to the center, where the stereocolumella is still strong. The secondary septa of the cardinal quadrants are still united at their inner ends, as are also some of the later ones of the left counter quadrant. Some of the others however have begun to separate into groups, which are only slightly united at their inner ends. This appearance is chiefly due to the fact, that they are cut at a higher level than those of the cardinal quadrants, because of the obliquity of the section. It should be noted that in the higher part of the section (*i.e.* in the counter quadrants) only spines occur, while in the lower part (cardinal quadrants) the dissepiments still persist to some extent. The tertiary septa join the secondaries in most cases, that is, they are continuous with spinous processes from the secondaries, these processes remaining as such when the tertiaries become free. Another section, about 2 mm, higher (Pl. I, fig. 10d reversed, text fig. 56) shows three of the septa of the right counter quadrant (left in figure) with free inner ends, but still united by inward convex dissepiments. The others are united centrally, those of the cardinal group forming a narrow horse-shoe-shaped wall around the fossula in which the cardinal septum has only a very slight development. Many of the dissepiments of the cardinal quadrants are now broken up into spines. Judging from the relationship of the septa, there are two secondary ones in the left (right in the figure) and 3 (the third a small one) in the right (left in figure) cardinal quadrants, those of each group are joined together and to the corresponding alar septum. There are six septa in each of the counter quadrants, while

* Minimum diameters are given, because, since the sections are oblique, these represent more nearly the true diameter of the circular sections.

the counter septum itself is thin. In the next section on the opposite side of the slab, Pl. I, fig. 11d (about 2.5 mm. higher, minimum diameter 10.5 mm.) the septa of the cardinal and some of those of the counter quadrants as well, are free, but the others are still united. The dissepiments are still present in some cases, but very thin. There are no spines but some of the tertiaries are still joined to the secondaries. In the last section finally, about 2 mm. higher, minimum diameter 11 mm. (Pl. I, fig. 12, reversed), the septa are all free at their inner ends, and the pseudocolumella has disappeared. Additional stereoplasm has, however, developed in the left cardinal quadrant (right in figure) which ties together the septa at their inner portions, where in the previous section they were entirely free. Spines have nearly, and dissepiments have quite disappeared, but some of the tertiary septa are still joined to the secondaries. There are still 3 secondaries in the right cardinal, and 2 in the left, (right of fig.) though here a thinner septum has appeared, while each counter quadrant has six secondary septa. The counter septum itself is very thin and thread-like at its inner end, giving the appearance of a counter fossula.

From the sections it is apparent that dissepimental tissue of the convex inward or cystose type, is characteristic of the early stages of the coral, the septa here being much thickened subsequently by stereoplasm. Later these dissepiments break up into spines, and finally these spines disappear. New dissepiments may, however, form in later stages.

So far the sections have not definitely indicated the existence of the horizontal carinæ characteristic of the genus, though some of the spines may be cross-sections of these. In longitudinal sections, and worn specimens of the species from Shansi, these carinæ are seen.

HORIZON AND LOCALITIES: A fairly complete specimen (Plate I, fig. 5a, b) was found in a dark nearly black calcilutite, where it is associated with a *Textularioid* and other Foraminifera. This was obtained by Dr. C. F. Erickson at Shih-lin Yuan, Kung Hsien, Honan. The specimen sectioned and described above came from a similar rock from the Poshan or Taiyuan series of Tung Chuang, I-Hsien, Shantung. This is associated with *Lophophyllum acanthiseptum*. Other specimens were obtained by C. C. Wang above the fourth coal seam at I-Hsien Shantung in dark crinoidal limestone. The species is not uncommon in the Kuantikou limestone of the Taiyuan series of late Viséan (or early Moscovian) age in the Taiyuanfu region, where it is associated with *Lophophyllum acanthiseptum* Grabau, from which it can not be distinguished by external characters, unless the calyx, or a section near it, is shown. The species appears to be widespread. Its age is probably in all cases late Viséan or early Moscovian.

Genera **LOPHOPHYLLUM** Edwards and Haime
and **LOPHOCARINOPHYLLUM** Grabau (gen. nov.)

The genus *Lophophyllum* is the terminal member of the family *Streptelasmaidae*, showing in its young stages the simple septal character of *Streptelasma*, with the interseptal spaces sparingly, or not at all furnished with dissepiments. The genus becomes differentiated from the other members of the family by the gradual thickening of the inner end of the counter septum while later this thickened portion is constricted off, so as to appear independently of the counter septum. This forms the characteristic flattened pseudocolumella of the genus. It is not a distinct upward growth from the base of the corallum as is the true columella, which is chiefly restricted to the Hexaseptata, but in the young stage of the corallum, is merely the central portion of one of the four primary septa, the counter septum. The constriction which separates it from this septum in the adult, is analogous to the constrictions which in some Hexaseptata separate the inner ends of all the septa of the earlier cycles, which then, in the adult, form a circle of distinct rods or *pali* opposite to the inner ends of these septa. Because of the similarity of origin, the name *pali-columella* is given to this variety of pseudocolumella. This palicolumella may remain flat, or it may be thickened by secondary stereoplasm, until it becomes a solid rod of circular section.

Lophophyllum is represented in the Carboniferous limestone (Dinantian) of western Europe by a number of species, in the majority of which the pseudocolumella has not yet become fully separated from the counter septum. This represents a more primitive stage in development than is found in typical Carbonic species, where the separation is complete in the adult. As is normal for the advanced genera of this family, the counter quadrants are accelerated, there being sometimes an excess of three pairs of secondary septa in the counter, over the cardinal quadrants. Acceleration of the counter quadrants is also shown by the early appearance of the first pair of secondaries of those quadrants, which appear to develop simultaneously with the four primary septa. (See Duerden 1902, and Gordon 1906).

As will be more fully shown under the description of *L. acanthiseptum*, the Chinese species appear to have a distinct origin, their youthful stages being characterized by the development of carinae of the *Lopholasma* type, visible in cross-section as septal spines. On this account they may be separated under the generic term *Lophocarino-phyllum* Grabau (gen. nov.) with *L. acanthiseptum* Gr. as the genotype. (For further discussion, see pp. 51, *et seq.*).

Lophophyllum proliferum (Mc Chesney.)

- 1859 *Cyathaxonia prolifera* Mc Chesney, Description of new species of fossils p. 75.
1872 *Lophophyllum proliferum* Meek, Geol. Rep. Nebraska, p. 144, pl. 5, fig. 4.
1873 *Lophophyllum proliferum* Meek, Geology of Illinois, Vol. V. p. 560, pl. 24, fig. 1.
1877 *Lophophyllum proliferum* S. A. Miller American Palæozoic fossils, p. 57.
1883 *Lophophyllum proliferum* Kayser, in Riechthofen China, vol. IV. p. 184, pl. XXIX, figs. 7-10.
1902 *Lophophyllum proliferum* Duerden, Johns Hopkins University Circular, Jan. 1902, with serial sections.
1909 *Lophophyllum profundum* Grabau & Shimer, North American Index Fossils, vol. I. p. 76, fig. 119. (Upper figure only.)

This typical North American Carbonic species has been identified by Kayser among the Upper Carbonic fossils of the Loping region. The specimens obtained by him, a dozen more or less imperfect individuals, show a gently curving simple horn-shaped corallum, from 2 to 3 cm. in length, and a calycinal diameter of 5.4 cm. The epitheca is thin, with moderately strong wrinkles; septal grooves well shown, exhibiting the pinnate arrangement. Short radiceiform epithecal prolongations are occasionally developed on the lower end. Calyx of circular section, moderately deep; fossula not recognized with certainty. Pseudo-columella exert, laterally compressed. Septa from 28 to about 50, alternating long and shorter, the longer ones (secondaries and primaries) reaching the pseudocolumella, and sometimes slightly twisted at their inner ends. A longitudinal section shows the presence of a few slightly arched tabulae in the basal portion.

The figures given by Kayser show the essential characters of the American form, the most pronounced feature of which is the laterally compressed and vertically striated palicolumella.

The compressed character of the columella is shown in Kayser's fig. 8, but in the calyx of the most perfect specimen figured by him, it appears to be thickened more than is normal for this species.

No other specimens of this coral have so far been obtained. It should however be noted that some specimens of *L. uncanthiseptum* show in the calicinal portion the essential characters of *L. proliferum* and can only be distinguished with certainty by sectioning.

HORIZON AND LOCALITY: The specimens described and figured by Kayser came from thin limestone beds intercalated in the coal series, in the Permo-Carbonic of Loping, Hsin-Chau-Fu district, province of Kiangsi. From the close analogy of the

Loping fauna with that of western North America, it is not surprising to find in it the American species of *Lophophyllum*, but apparently this does not occur in any of the other Carbonic faunas of China. The possibility, that the Loping corals belong to one of the species described below, rather than to *L. proliferum*, must not be overlooked, though it is not likely that it is referable to one of the species from the Taiyuan series, because of the difference in age.

Lophophyllum pendulum Grabau (sp. nov.)

Plate I, Figs. 15a, b. (Holotype) Figs. 16a b, 17a b, Text fig. 57 (paratypes).

(cfr. *Lophophyllum proliferum* var. *sauridens* White (?) Kayser in Richthofen
China, Vol. IV. p. 195 pl. XXIX, figs. 11-13.)

HOLOTYPE: Corallum with slight curvature only in the lower part, regularly expanding at the rate of 1 in 2 mm. of length, its calicinal diameter at a length of 22 mm. being 11 mm. There are a few irregular but not overprominent growth-wrinkles, but the epitheca is thin, showing the strongly-marked septal grooves with their pinnate arrangement. In the adult the epitheca is, however, strongly thickened by secondary deposits of stereoplasm on the inside, without however obliterating the external features. In the specimen shown in Plate I, fig. 15, the thickness attained by the wall in this manner is slightly over 1 millimeter. Counter quadrants strongly accelerated; the counter septum is pronounced, and still continuous with the much enlarged pseudocolumella. Near the periphery, this septum is about 0.4 mm. in thickness, due to secondary deposit of stereoplasm, but thins away to about half this thickness at the pseudocolumella. It is flanked by a pair of septa which reach about half way to the center, and outside of this by another stronger pair which very nearly reaches the pseudocolumella. These septa are probably the first pair of secondaries, the shorter ones, nearer the counter septum, being the first pair of tertiaries which are longer than the other tertiaries of the corallum. These five septa are separated by very short septa, which would, from their appearance, and similarity to the tertiary septa of the remainder of the corallum, be regarded as belonging to that order. If however the designation above given is correct, as the serial development of corals of this genus, described by Duerden, would lead us to expect, those four short septa of the counter quadrants must be regarded as quaternary.

Beyond the longer septa, here designated the first pair of counter secondaries, are six further septa on each side, somewhat shorter than the first, except the last two, which are much shorter, reaching at the point of section only half-way to the center.

Between them are short tertiaries. Thus there are seven secondary septa in each counter quadrant, together with seven short tertiaries (the last next to the alar), a long tertiary next to the counter and two short quaternaries, or 17 in all.

The alar septa are less prominent than the counter, not reaching the pseudocolumella in the plane of the section, and they are followed by three slightly shorter secondary septa and four very short tertiary septa in each cardinal quadrant, the last of the tertiaries being next to the much shortened cardinal septum, which by its abortion, forms a prominent fossula. Thus the total number of septa in each cardinal quadrant is 7, as compared with 17 in each counter quadrant.

A few of the septa are characterized by short hook-like appendages. The pseudocolumella is centran, large and broadly oval in section, due to excessive thickening by stereoplasm. In the holotype its cardino-counter diameter is 3.3 mm. and its lateral diameter 2.5 mm. The center still shows indications of the original flat character comparable to that of *L. proliferum*.

PARATYPES: Another specimen of the same species associated with the preceding, but with fewer septa (a younger specimen, 16 mm. long) was sectioned near the middle where the diameter is 6.5 mm. It shows the septal arrangement represented semidiagrammatically in text fig. 57. The septa are distinctly arranged in four groups though in the upper part of the same specimen they are radial (except for displacement by crushing of the specimen). The counter septum is margined by two short tertiary septa. The palicolumella is already separated from it and surrounded by a distinct zone of stereoplasmic material analogous to that which thickens the septa to such an extent, that only minute interseptal loculi (represented in black in the text figure) remain. In spite of the deposit of stereoplasm, the central flat character of the pseudocolumella is pronounced. Surrounding it is a series of minute paliform structures which appear to be the similarly severed inner ends of the secondary septa, though not always aligned with them. Such structures are also indicated in *Lophophyllum proliferum* in a section near the upper end, given by Duerden (1902 Fig. 7) and reproduced by Gordon (1906, Figs. 7 & 14).

Dissepiments very sparingly developed. In the upper portion they generally appear to be absent.

Two silicified specimens from the Upper Dinian (?) limestone of Honan, show further variations of this species. One of these (Plate I, figs. 16a, b.) is moderately curved, and has the cardinal septum on the side of greatest curvature. The other (Plate

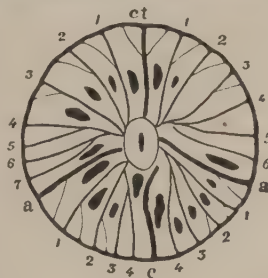


Fig. 57.

Figure 57. *Lophophyllum pendulum* Grabau. Cross-section of one of the paratypes near the middle of the caliculus, showing arrangement of septa (c, cardinal, ct, counter, a, a, alar septa). Enlarged.

I, figs. 17a, b), less well preserved, is more strongly curved, and has the counter septum nearly but not quite on the side of the greater curvature. The pseudocolumella is exert, broadly oval in section and continuous with the counter septum *i.e.* the thickened part of it is in such a connection, the original inner portion has been dissolved away. Calyx of moderate depth, the septa radially arranged except those of the cardinal quadrants which on the inner side still bend slightly towards the central plane. As the septal grooving on the outside of the corallum is largely obliterated in silicification, it is not possible with certainty to locate the alar septa, but from the appearance of the septa themselves, it seems that there are three secondary septa in the cardinal quadrants, the cardinal septum being very short and situated in a broad, well defined fossula. Very short tertiary septa occur in all the interspaces. The counter septum is flanked by the intermediate septa, regarded as enlarged tertiaries, with minute quaternaries on either side (4 in all.) The succeeding septa are strong and reach the thickened pseudo-columella except where broken. There are six of these on one side and 5 on the other. Minute tertiaries occur in the interspaces. Altogether then, counting septa of secondary and higher orders, there are 15 and 13 in the two counter quadrants while each cardinal quadrant has only 7. Dissepiments are wholly wanting in the upper part of the corallum.

The measurements of the specimen illustrated in Plate I, fig. 16a, b are: length on curved side (estimated) about 27 mm. (the apical portion is broken away); diameter of calyx 10 mm. Cardino-counter diameter of pseudocolumella 2.5 mm., transverse diameter 1.5 mm.

COMPARISONS. This species, while of the general size and form of *L. proliferum*, differs from it in several important features. The form of the Chinese species is more gently tapering, while the much thickened, broadly oval pseudo-columella, still in connection with the counter septum, readily distinguishes it. This species is as a rule more accelerated in the counter quadrants than *L. proliferum*, but this is not always readily ascertainable. The fossula too, is more pronounced than it is in *L. proliferum*.

Kayser has figured several specimens of a slender *Lophophyllum* with rod-shaped pseudocolumella, which he obtained with *L. proliferum* (?) from Loping. He refers these doubtfully to White's variety *sauridens* of *L. proliferum**, although the latter are much larger. He speaks of the columella as more or less polygonal, but his figures show the section to be circular. Unfortunately its relation to the counter septum can not be determined, and as no new material has come to hand, the relationship must for the present remain in doubt. The difference in the form of the columella would seem to be

* White in Wheeler's Rep. Expl. Exped. west 100th mer. p. 101. pl. 6. fig. 4. 1875.

a distinctive character, however. In any case, our species can not be referred to White's variety.

HORIZON AND LOCALITIES: The holotype, having been sent to America and back, was unfortunately separated from its label, and hence the locality is in doubt. It appears to have been obtained from a shaly deposit (judging from its preservation) and probably came from south China (probably Yunnan). Another specimen, of which a section is given in text fig. 57, was associated with it, as was also the holotype of *Tachylasma cha.* The horizon is probably late Lower Carboniferous (Dinantian) though judging from the acceleration, it might be regarded as younger. The paratypes illustrated in Plate I figs. 16 & 17 came from a black marine calcilutite with *Productus* etc., obtained by C. F. Erickson at Shih-lin-yuan, Kung Hsien, province of Honan, and are probably of the same age. Another specimen of this species was obtained from black crinoidal limestone, at Tung Chuang, I-Hsien, Shantung. (Poshan or Taiyuan Series). It also shows delicate spines on some of the septa. Two specimens have been obtained by Mr. Norin from the Hsiehtao limestone near Tsin-szü-tsun 42 li S. W. of Tai-yuan-fu, Shansi. This limestone is in the Taiyuan series, which is definitely assigned to the Dinantian (Lower Carboniferous) representing probably the Viséan of Europe. Still another specimen was obtained by Mr. Norin in the Shihchinakou limestone of the Taiyuan series, at Kian-mên-chien S. E. of Taiyuanfu. A specimen apparently of this species was obtained by Messrs. C. C. Liu and J. C. Chao in a gray limestone with *Productus* sp. in the coal series of the Changhing Coal Mine, Chekiang.

Lophophyllum (Lophocarinophyllum) acanthiseptum Grabau (sp. nov.)

Plate I, figs. 6 a, c; 7 a, c; 8 a, c, e; 9 a, c, e, f; 10 c; 11 c; 18-21.

Text figures 58-65.

(cf. *Lophophyllum frechtii* Lorenz, Zeitsch. d. deutsch. geol.

Gesellschaft. 1906, p. 91, pl. VI, fig. 7.)

Corallum small, slender, enlarging somewhat irregularly and moderately curved. Epitheca originally thin, but showing strong concentric growth lines which on crossing the strongly marked interseptal ridges give them a regularly nodose or subspinose appearance. Occasional irregularities of growth occur. On the inside, the epitheca is thickened by secondary deposits of stereoplasm. Calyx apparently of moderate depth but rarely shown because of compression of the specimens. Pseudocolumella prominent, laterally

compressed, and rather pronouncedly exert. Where the epitheca is worn away, the septa are seen to have numerous strong irregularly-placed, generally alternating but occasionally nearly opposite, carinae, which extend outward and have their ends bent upwards.

These carinae are in all respects like those of the genus *Lopholasma*. In transverse section, at right angles to the axis, one or the other of the upturned edges of the carinae is frequently seen, appearing as a thin lateral branch septum, parallel to the septum to which it belongs, or as a slender spine from the septum and more or less parallel to it; or the septum appears to be split longitudinally for a greater or less length, thus forming a "double septum". In oblique section the carinae appear as curving spines upon the sides of the septa.

A section of the pseudocolumella a short distance below the calyx, has the appearance of that in *L. pendulum*, being greatly thickened by stereoplasm. Farther down, it is merged in the general stereoplasmic mass, which unites the inner ends of the septa. It is pendulant from the counter septum.

A specimen (Plate I fig. 20) 23 mm. in length along the curvature, has a diameter of about 9.5 mm. at the upper end, which is some distance below the calyx rim. The specimen shows regular tapering of about 1 in 2.4. Other specimens show more rapid tapering. Dissepiments sparingly developed.

A long slender specimen (Pl. I fig. 21) from the Hsiehtao limestone of the Taiyuanfu region (loc. 39), appears to represent extremes of elongation in this species. The length preserved from the calyx rim to the basal part of the fragment is 41 mm., and the diameter at the base is 7 mm. The calyx is crushed, but 15 mm. below its top the diameter is 9.5 mm. The rate of tapering is thus about 1 in 10, and the total length of the specimen was probably between 50 and 60 mm. The columella is strongly exert and tapering upwards.

A number of sections of this species at oblique angles have been obtained, and these show characters not ordinarily seen in normal cross-sections. They also show the progressive changes in development and will therefore be described at some length.

The largest section seen (Text fig. 58) has maximum and minimum diameters of 15 and 19 mm. respectively, the maximum diameter being due to the obliquity of the section.

This specimen, which came from Ch'i-Ts'un, I-Hsien, Shantung, shows a well-developed, laterally compressed pseudo-columella, of elongate oval section, with a tapering end towards the counter septum with which, at this stage, it still maintains

a faint connection. Its transverse diameter is 1.4 mm. its axial, about 2.5, or with the tapering prolongation 4 mm. The counter septum is slightly stronger than the others, tapering to the point of junction with the pseudo-columella. The septa of the left side (the right as the section is oriented in the figure, the section being reversed), are practically all of the same size so that it is not possible to say if the first long septum is a secondary or a tertiary one. Nor is it possible in this section to determine the alar septa. Altogether there are 10 long septa in the left lateral quadrants (right in figure 58) and 10 in the right, (left in figure 58) differing markedly in character. On the left (right*) they are all simple except two, and separated by shorter septa, which are longer in the counter than in the cardinal quadrants. The last two septa of the left (right) cardinal quadrant are irregularly thickened, and from the salient points project short horn-like spines, an outer, which projects laterally from the septum on the anticardinal side, and an inner (nearer the center of the corallum) on the cardinal side, which projects inward.



Fig. 59.

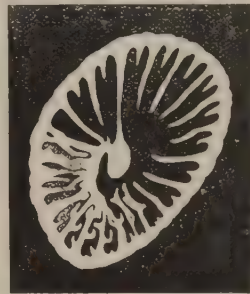


Fig. 58.

Figure 58. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Gr. Oblique section of the largest specimen seen ($\times 2.5$) (reversed)
Figure 59. Another specimen sectioned through the calyx, showing freely projecting pseudocolumella.

The cardinal septum is shorter than the secondary septa. It is thickened for half its length from the periphery and then divides into three parts, an inner thin prolongation, deflected towards the right, and two somewhat shorter spine-like spurs. This gives it the appearance of an irregular *trident*.

The secondary septum next to it, on the right, (left in fig. 58) has three short inward projecting spurs, one on the anticardinal side close to the point of origin, a second on the cardinal side, at about one fourth the length of the septum, and the third on the anticardinal side at a little more than half the length of the septum. The next preceding septum is similar, but has an additional blunt spine on the cardinal side. The other septa are similar, but have progressively less developed spines as we proceed counterwards, the spine on the cardinal side being finally the only one, this then being more strongly developed. The last two septa are without spines. All the long septa on the right side (left in fig. 58) except that next to the counter and that next to the cardinal are joined together by stereoplasm, and the close approximation of the last septum of the

* The word in parentheses refers to the position in the figure which, it must be remembered, is reversed.

cardinal quadrant to the preceding also gives it the appearance of being joined to the others.

Another specimen from this locality (Text fig. 59) is sectioned obliquely from side to side the minimum and maximum diameters at the point of sectioning, being 9 and 12 mm. respectively. This section is only a short distance below the calyx rim, and shows only the upper ends of the septa and the pseudocolumella. The latter is isolated, showing its exert character. Its longer diameter is 1.3 mm. its shorter 0.5 mm.

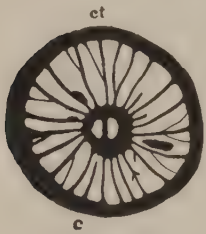


Fig. 60

Figure 60. *Lophophyllum* (*Lophocarino-phylum*) *acanthiseptum* Grabau. Section of the specimen shown in fig. 59, about 15 mm. lower; reversed (c. cardinal; ct. counter septa). (Enlarged about $2\frac{1}{4}$ times).

There are 19 secondary septa in addition to the four primary which, except the cardinal, are indistinguishable from them in size and disposition, thus making 23 in all of the longer septa. The cardinal septum is however slightly shorter. Short tertiary septa occur between the others. Both the epitheca and the septa are thickened by secondary stereoplasm the former more than the latter. No septal spines are shown in this section which is indistinguishable from one of *L. ropliferum*.

The corallum is incomplete, its greatest length was originally in the neighborhood of 25 mm. It is further strongly curved, and the sides show well the septal grooves.

A section about 15 mm. below the one described, where the corallum has a diameter of 12.5 to 13 mm. is shown in text figure 60 (reversed). The septa are all united medially by stereoplasm while the pseudocolumella is continuous across the center of this deposit, and apparently is still a part of the counter septum. In the cardinal quadrants several septa show the short thick curved spine-like processes, characteristic of this species, these extending either laterally or for the most part pointing outwards (towards the periphery). Some of them however point inwards. Dissepiments present but not prominent.

A section of a corallum from Tung Chuang, I-Hsien, Shantung, seen from the basal side, is shown in Pl. I. fig. 6a. The maximum and minimum diameters are 14 and 7.5 mm. respectively, the difference being due to the obliquity of the cut. The section is reversed with reference to the orientation adopted. The epitheca is strongly thickened by stereoplasm. The cardinal septum is short and simple, forming a large fossula (lower left hand side of figure). The two secondary septa on the right next to the cardinal, (left in figure) are long simple and radial, but united at their inner ends by stereoplasm. All the other septa are united into one group by stereoplasm which also includes the pseudocolumella, the outlines of which are visible in the center of the mass. The third (apparently the alar septum) and the fourth septa on the right (left in figure) are also

simple, but the next one has a strong outward pointing spine on its inner anticardinal side. The next two on this side have two spines each, one on either side, while in the next two the spines have developed to such an extent as to make the septum appear double. This appearance is due to the fact that the upturned margin of the carina is sectioned.

The next one is simple, without spines, and then follows the counter septum which has a spine on either side, the bases of the spines being in apposition.

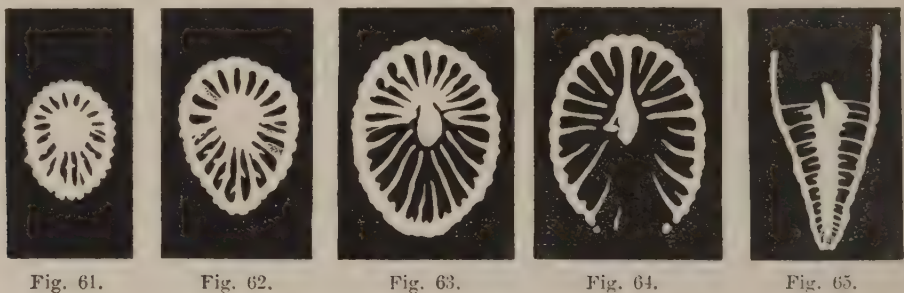
To the left of the counter septum (right in figure) are five septa, each with from 1 to 3 spines. The sixth septum has a spine joining it to the periphery while the seventh is short and joined to the alar (8th) in its outer portion. It becomes free higher up as shown in the next section. The ninth is a double septum and the tenth, next to the cardinal, a simple strong septum. There are thus ten long septa on each side of the cardino-counter axis. One on each side is an alar septum which leaves nine for the two quadrants. So far as the septa themselves permit us to judge, there are seven septa in each counter and only two in each cardinal quadrant, which would indicate an enormous acceleration of the counter quadrants. No dissepiments are shown in this section.

A section of this specimen 3 mm. above that just described (nearer to the calyx rim) and parallel to it, is shown in fig. 7a, Pl. I. This section is normally oriented, the corallum being viewed from above, and hence the parts are reversed with reference to the preceding section. Both sections are at angles of about 45 degrees to the axis of the corallum, the counter quadrants being cut much lower than the cardinal. In this section the counter quadrant is still attached to the columella which is of oval section about 2 mm. wide, and about 2.5 mm. long (it must be remembered that the length is exaggerated owing to the obliquity of the cut). In the section the length is 3.3 mm. The spines of the counter septum have been displaced laterally being no longer directly opposed as in the previous section. To the left of the counter septum (which corresponds to the right in the previous section) there are six simple septa with inward pointing spines, followed by a short septum without spines, and then by a long septum which is the alar septum. These two were apparently united in the lower section but have now become completely and widely separated. Beyond the alar, there are two shorter septa before the cardinal is reached. This makes 10 septa in all, and shows that the double septum has again united into a single one (*i.e.* the double appearance was due to sectioning of the carina edge).

A partial section, perhaps 2 mm. higher (Pl. I, fig. 8a reversed), shows only the counter quadrants. The septa of this quadrant on the right (left of the counter septum as seen in the preceding section), which were strongly spinous, have lost their spines towards the upper edge of the calyx and become simple (here shown on the right side). The

counter septum is stronger than the others, but the columella does not reach so high, being unrepresented in this section.

A younger individual of this species is also shown in this rock fragment. Six successive sections of this are shown in figs. 7c, 8c, 9c, 10c, & 11c, Pl. I, these sections being nearly at right angles to the axis. Four of these (7c-10c) are shown enlarged in text figures 61-64. In the youngest (reversed) which is 2.5 mm. in diameter, the interseptal spaces have been almost obliterated by the deposition of stereoplasm on the septa. Strong interseptal ridges and septal grooves are, however, shown on the outside.



Figures 61-65. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau. Sections shown in Plate I, figs. 7c, 8c, 9c, 10c and 9f enlarged about $2\frac{1}{2}$ times. Figs. 61-64. A series of slightly oblique, transverse sections showing development of septa and pseudocolumella. 61 and 63 are normally oriented, 62 and 64 are reversed in position. Fig. 65. Median longitudinal section showing the thickened pseudocolumella, and the *Lopholasma*-like character of the carinae, which appear here as horizontal lines. (Enlarged $\times 3$).

The second section is 3 mm. higher, on the opposite side of the same slice (Pl. I, fig. 7c normal, text fig. 61). It has maximum and minimum diameters of 6 and 4.5 mm. respectively, and shows the cardinal septum well developed with a spine on either side. On the left side there are three septa in the cardinal quadrant joining one another and the alar septum, which is long. There are four septa also joined into a group, in the counter quadrant. On the opposite side these four are well developed and a fifth, much thinner, has begun to appear next to the alar. The third (innermost) septum of the cardinal quadrant on this side is much smaller and shorter than that on the opposite side. Several of the septa in the cardinal quadrants have short spines, but those of the counter quadrants seem to be without them, or with only very incipient ones. All the septa are united in the center into a stereocolumella.

A third section is taken about 2 mm. higher on another slice (Pl. I, fig. 8c, text fig. 62) where the diameters are 7.5 and 6 mm. respectively. The position here is reversed so that the parts on the right side correspond to those on the left in the preceding section. The septa of the cardinal quadrants are still spiny, indeed more strongly so than in the preceding section, while those of the counter quadrants show no spines. The alar septum on the left (right in section) is double, and the three septa of

each cardinal quadrant have now become distinct. There are now five distinct septa in the counter quadrant on the right (left in section) while a thin fifth one appears on the left (right in section). All the septa are still united into a stereo-columella, the palicolumella not yet appearing in distinct outline. There are as yet no tertiary septa. The septal grooves and interseptal bulgings are still very strong. Epitheca moderately thickened by stereoplasm.

The fourth section (Pl. I, fig. 9e, text fig. 63) is 3 mm. higher on the opposite side of the same slice with section 3. Here the orientation is again normal. The diameters are 10 and 7 mm. respectively. The septa of the cardinal quadrants are now free and radial. There are 2 on the right and 3 on the left, the third one on the left (next to cardinal), being shorter than the others. The cardinal septum has also become shortened to half its previous length (proportionately). All have lost their spines. The alar septa are the longest of the free septa. The counter septa are still united by stereoplasm, except the last on each side which is free, and several of them are slightly spinous. There are six on the left and seven on the right. The palicolumella is now distinct in outline, but still united to the counter septum and to the crescentiform stereoplasm, by its counter side. It is of narrow pear-shaped outline, with maximum width of 1.2 mm. Tertiary septa have now appeared in the cardinal quadrants and the septal grooves and interseptal ridges are no longer so strong. Epitheca moderately thickened by stereoplasm.

The fifth section (Pl. I, fig. 10c, text fig. 64) about 2 mm. higher on another slice, again shows the position reversed. The diameters are 11 (?) and 8 mm. The septa of the counter quadrants are now free, those next to the counter being shorter than the others. The counter septum is still united with the palicolumella. The spinous character of the septa has now disappeared. The sixth and final section (Pl. I, fig. 11c) is close to the calyx margin. All the septa are shortened and the columella is free. It is strongly compressed laterally, and this and its exert character gives the calyx the appearance of that of *Lophophyllum proliferum* from which it could only be distinguished by the other sections.

Two longitudinal sections (Plate I, figs. 8e, 9e, 9f and text fig. 65) of small individuals are associated with the transverse sections, and these are referred to the present species despite their remarkable character and their association in the same slab, with sections of *Lopholasma carbonaria*, as well as *Lophophyllum acanthiseptum*. Their significance consists in the fact that they resemble to a remarkable degree the sections of *Lopholasma carinatum* Simpson a Devonian species. These are shown in text figures 52 and 53 p. 43 reproduced from Simpson (1900 p. 207 Fig. 21-22). That these sections

are referable to *Lophophyllum acanthiseptum* and not to *Lopholasma carbonaria* is shown by the different character in the young of the latter species in which carinae are apparently absent while the septa are so thickened as to fill the entire space (see p. 44). That these sections belong to *L. acanthiseptum* is also shown by the projecting pseudo-columella.

In the median section (Plate I, fig. 9f, text fig. 65) the calyx is deep and the pseudo-columella projects into it, extending upwards from the bottom of the calyx. Distinct, nearly horizontal carinae are shown, proceeding from the columella, and reaching the cup wall, when the section is parallel to the septa. In the excentric section (Pl. I, figs. 8e, 9e) the width of these carinae and their irregular disposition on the sides of the septa are shown. Their outer margins are seen turning upwards. It is these carinae which in section appear as spines, especially when the sections are oblique, as they are in figures 6-11 in Plate I. In parallel section the edges of the carinae appear as branch septa.

The almost absolute correspondence of these sections of young *L. acanthiseptum* (except for the projecting pseudocolumella) to those of adult *Lopholasma carinatum*, indicates beyond doubt that the Devonian form holds ancestral relation to our species. As no such structures have been recorded in American species of *Lophophyllum*, while they seem typical of all the Chinese species,* the question of a separate origin of these forms is at once suggested. Our species quite evidently is derived from a *Lopholasma* type of ancestor, possibly directly from the Devonian *L. carinatum*. The development of the American species on the other hand suggests that it is derived from an ancestor of the *Stercolasma* type, possibly from *Stercolasma rectum* in a direct line. If that is the case, our species can not be referred to *Lophophyllum*, but represents rather a parallel development of the *Lophophyllum* structure (i.e. the palicolumella). This might be indicated by the generic name *Lophocarinophyllum* nom. nov. applicable to the Chinese Lophophylloid types.

The total absence of dissepiments and tabulae in this species is remarkable and would lead some to place it with *Cyathaxonia*. However the septal development and the origin of the columella are quite distinct from those in *Cyathaxonia* (see *postea*) as is also the development of carinae.

HORIZON AND LOCALITIES: This species was obtained in a brownish limestone (calcilutite) associated with small crinoidal fragments at Chi-Ts'un, I-Hsien, Shantung above the third coal seam, and in a dark blackish crinoidal limestone, associated with

* The species referred by Kayser to *L. proliferum* (ante p. 47) also, apparently, possesses these carinae as indicated by Kayser's section (*loc. cit.* pl. XXIX fig. 10) though these have been referred to as tabulae. They however suggest the carinae very strongly.

Lopholasma carbonaria at Tung-Chuang I-Hsien, Shantung. The age is Carbonic, possibly late Dinantian (Taiyuan series). The species is common in the Kuantikou limestone of the Taiyuan series in the Taiyuanfu region (locs. 27, 38) and also in the Hsiehtao limestone of the same series (loc. 39) where it was collected by Erik Norin. These beds are at present referred to the late Viséan.

Lorenz figures a section of a coral from Poshan under the name *Lophophyllum frechi* sp. nov. Unfortunately it is impossible to determine the generic standing of Lorenz's form from the section. It might belong to the species here described, or it may be a section of the form described above as *Lopholasma carbonaria*. The stage represented by Lorenz's section is practically alike in the two genera. This makes it necessary to discard Lorenz's name.

Genus **ARACHNOLASMA** Grabau (gen. nov.)

Corallum simple, of moderate size, subcylindrical in the mature, regularly tapering in the young portions. Septa numerous, radiating; dissepiments abundant; center of corallum occupied by a pali-columella, which is joined to the counter septum in the early stages but is free from it throughout the greater part of the corallum. In form the pseudocolumella is laterally compressed and elongated in the direction of the cardino-counter axis, having thus essentially the character of the pseudocolumella in *Lophophyllum*. The pseudocolumella is amplified and strengthened by supplementary tissue in the form of irregular elevated, converging plates, which in section give the appearance of a coarsely cystose structure, which has a rather marked resemblance to a spider's web. Cardinal septum only moderately aborted, there being a scarcely defined cardinal fossula.

The large number of radial septa, the very abundant dissepiments, and the peculiar character of the axial part around the columella, as well as the early separation of this from the counter septum, distinguish this genus from *Lophophyllum*.

GENOTYPE:—*Lophophyllum sinense* Yabe and Hayasaka.

Arachnolasma sinense (Yabe and Hayasaka)

Text figure 66.

1920 *Lophophyllum sinense* Yabe and Hayasaka, Palaeontology of Southern China, plate VI figs. 2a-2g.

This species was figured by Yabe and Hayasaka, but, so far as I am aware, has not been described. However, the figures are well executed and show all the details, including five cross-sections and a partial longitudinal section.

The species is much larger than any known *Lophophyllum* and has more the aspect of a slender *Cyathophyllum*. The maturer portion is nearly cylindrical but the young portion shows gradual tapering with slight curvature. The epitheca is of moderate thickness, allowing the septal grooves and interseptal ridges to be seen on the exterior.

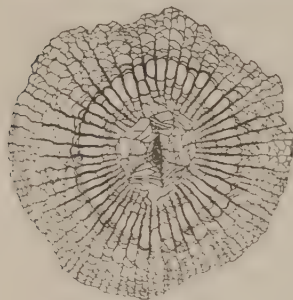


Fig. 66.

Figure 66. *Arachnolasma sinense* (Yabe and Hayasaka). Copy of one of the cross-sections (enlarged $\times 1 \frac{1}{2}$) figured by Yabe and Hayasaka.

In the youngest section shown, where the diameter is only about one-third that of the adult, the columella is continuous with the counter septum, but in all the others it is free. Even in the youngest state shown, the spider-web arrangement of the cysts around the columella is seen and this persists throughout.

In the largest section shown (diameter 28 mm. text fig. 66) there are 49 well-developed septa (1st and 2nd orders) with less well-marked tertiary septa. Towards the periphery, the septa become somewhat illy defined merging into a more or less pronounced cystose zone. They stop short of the center, where the arachniform cysts occupy about $\frac{2}{7}$ of the diameter. The septa are thickened in their middle third but become thin both towards the center and the periphery. Sometimes a strongly marked series of dissepiments occur at the point where the thickening commences, giving the appearance of an inner wall.

The pseudocolumella is long and narrow in the maturer parts but more oval in the younger stages.

HORIZON AND LOCALITY: The specimen figured by Yabe and Hayasaka came from the Lower Carboniferous beds East of Ai-Chia-Ping, Wei-Ning-Hsien, Province of Kweichow. No further material has been obtained.

Genus **AMPLEXUS** Sowerby

This genus was founded upon the Dinantian species *A. coralloides* Sowerby, which is characteristic of the Carboniferous Limestone of Ireland, England, Belgium, the Urals and more doubtfully of the United States. Its essential character are: the

cylindrical form, above the rapidly tapering initial portion; the thin equally developed septa, which are widely spaced and do not extend beyond the marginal portion of the corallum; and the well-developed and numerous tabulæ which extend entirely across the corallum in a more or less regular manner and are close together. The septa extend as narrow ridges upon the outer margins of the tabulæ.

In typical British specimens of *A. coralloides*, the fossula is only slightly or not at all developed. Edwards and Haime state (1852): "A small depression, corresponding to the septal fossula, is visible near the wall, and is always more distinct on the last tabula than on the others" (p. 174). The fossula is an incipient siphonofossula, as might be expected from the abundant development of tabulæ. In the large specimen figured by Edwards and Haime, this is not shown, nor is there any apparent shortening of the cardinal septum. The small cylindrical form, which should probably be regarded as a distinct mutation, shows however the faint bulging on the under face of the tabula, together with a slight shortening of the septum at this point (presumably the cardinal septum). De Koninck (1872 pl. V. figs. 1a 1b) figures a large specimen, probably from Belgian rocks (Dinantian), which shows a well-developed siphonofossula with an aborted (cardinal?) septum. Thus it appears that in the typical species of the genus the siphonofossula is developed only in the adult stages of accelerated individuals, but is absent in others and in the young. (It is evident that the small cylindrical form figured by Edwards and Haime *loc. cit.*, is not the young of the larger form, but the adult of a slender variety). The young conical forms figured by Edwards and Haime, and by de Koninck, are without a fossula, and in form are streptelasmoid. They further agree with primitive *Streptelasmaida* in the absence of dissepiments or other endothecal tissue, except the tabulæ, while the absence of the fossula in the young shows that the form can not be derived from the zaphrentoids in which this is developed at an early stage. Unfortunately no developmental studies of the young of *A. coralloides* have been made and we therefore do not know if the counter quadrants are accelerated as is the case in the *Streptelasmaida*. The apparent close agreement, however, of the young of *A. coralloides* with the adult of *Amplexus hamiltoniæ* from the Hamilton (Middle Devonian) of New York State (U. S. A.)* is evident. This form is a typical streptelasmoid in the young, showing the quadripartite arrangement of the septa which reach to the center. This is sometimes retained in specimens up to the diameter of 6 mm. or more. In others the change towards an amplexoid structure appears earlier. The young is without tabulæ, but these develop in the neanic stage, when the septa begin to shorten. Tabulæ are

* See Grabau and Shimer 1909. N. A. Index fossils I, p. 59. fig. 86.

never so numerous or crowded as in the adult *A. coralloides*, and this is to be expected in an earlier, probably ancestral, form. This is probably also the character of the young of *A. coralloides*.

It must be clearly understood, that the amplexoid character, *i.e.* the well-developed tabulæ and shortened septa, is a purely homœomorphic character, indicating a stage in development, and not necessarily genetic relationship. In fact these characters are known to reappear in a number of distinct genetic series.

Lindström has described several species from the Silurian of south China, which he refers to *Amplexus*. Of these his first species *A. viduus* can not be left under this genus. It is a compound corallum, composed of a number of distantly placed narrow cylindrical corallites, 4 mm. in diameter. Septa are not visible but tabulæ are very numerous. This form is here referred to the genus *Synamplexus* nom. nov.

The two other species described by Lindström are more fully discussed below. They too are probably not referable to the same genus with *A. coralloides*, but until further material is obtained, which will permit the study of young stages, their precise generic reference must remain in doubt.

In the Middle Devonian of North America we find several other species with amplexoid characters. The most characteristic is generally identified as *Amplexus yandelli*. This is however not the species first described under that name by Milne Edwards and Haime (1851, p. 344, pl. 3. fig. 2). That form is a zaphrentoid with a well-developed siphonofossula, and belongs to the genus *Siphonophrentis* O'Connell (1914) (*Siphonophrentis yandelli* (E & H)). Here probably also belongs *Amplexus cornubovis*, though this species may belong to the genus *Siphonophyllia* Scouler, where it was placed by O'Connell on the supposition that it has a marginal vesicular zone. The figure of *Amplexus yandelli* given by Lambe (1901, pl. 9, fig. 4, 4a 4b) and reproduced by Grabau and Shimer (1909, p. 58 fig. 85) appears to be that of a true *Amplexus* however. To this species the name *Amplexus yandelli* must be restricted and the authorship credited to Billings, though the first illustration was given by Lambe. In this association probably belongs *Amplexus exilis* Billings, from the Onondaga limestone (Middle Devonian) of Ontario. That species is characterized by extremely short septa, their number however being large (64 or more). *Amplexus cingulatus* Billings, from the Upper Silurian beds of the Bay of Chaleurs and l'anse ou Gascon, is probably not a true *Amplexus*.

The species described below as a variety of *Amplexus spinosus* de Koninck, is probably to be regarded as a valid member of the genus.

Amplexus (?) distans Lindström

1883 *Amplexus distans* Lindström, in Richthofen China Vol. IV. p. 63. Pl. VI, figs. 1 & 5.

This is a simple corallum, of moderately straight form, conical, and gradually increasing in width upwards. Septa very short measuring only 4 mm. in length where the radius of the caliculus is 12.5 mm. (diameter about 25 mm.). In transverse section the septa are broad, rapidly tapering to a point, which is bent somewhat sideways. Between the septa, there is developed a gray stereoplasm, forming a narrow peripheral septal, or stereoplasmic ring. In longitudinal section the septa appear as narrow, longitudinal ridges, furnished with distant bent, and sharply pointed spinous prolongations. Curved, and strong dissepiments occur on the spiniform processes of some of the septa. Tabulæ thin, and distant, five in the space of 22 mm.

The amplexoid characters of this species consist of the shortened septa and the tabulæ, features which are correlative, and are repeated in a number of genetic series. The present species is in some respects more highly specialized than the Devonian species, and it may be seriously questioned if it can be considered congeneric with the typical species of the genus. This problem can only be settled by a study of the young stages. Then it will probably be found, that this species is an independent development from Ordovician streptelasmoids.

HORIZON AND LOCALITY: This species is known only from fragments obtained from bed *i* of the Silurian series of Tsau-tien in north-east Szechuan.

Amplexus (?) appendiculatus Lindström

1883 *Amplexus appendiculatus* Lindström, in Richthofen China, vol. IV, p. 63. Pl. VI, figs. 7-8.

Corallum broadly conical, with deep calyx, the walls of which descend vertically on the inside. Rootlike proliferations arise from the margin of the calyx as in *Omphyma* and other Palæozoic corals. In section these proliferations appear nearly solid, having been filled by stereoplasmic deposit on the interior. Only a slender median axial tube remained which later was filled by lighter-colored lime carbonate.

The longer septa (primaries and secondaries) are narrow and straight, reaching nearly to the center of the calyx. The tertiary septa between are very short and sharply pointed. In longitudinal section the septa appear marked by obscure cross stripings. Tabulæ closely crowded and nearly horizontal. Width of calyx 31 mm.

This species differs from others, (except *A. spinosus*) according to Lindström, in the possession of rootlike proliferations, though these are not shown in Lindström's figure. Here as in the preceding species we may question the propriety of placing this form in the genus *Amplexus*, though from fragments alone no other reference seems possible. That it is an amplexoid type, is evident, and that it was probably derived from an earlier streptelasmoid is suggested by the simplicity of its internal structure. It is certainly distinct from those Devonian species the young stages of which have been investigated (i.e. *A. hamiltoniae*) being much more specialized and quite evidently derived from a different ancestor.

Lindström figured two sections of an elongated form which he considered a variety of this species (Richthofen IV. Pl. VI. figs. 11-12) The sections represent opposite sides of a slice 5 mm. in thickness. The septal arrangement here is that of a very primitive streptelasmoid. In the smaller section, the septa still show some indication of grouping, and for the most part reach the center; two indeed from opposite sides (the cardinal and counter?) are joined in the center. In the larger section, five millimeters higher, the septa are mostly radial, and do not quite reach the center. Dissepiments very sparingly developed; no fossula.

These characters indicate the persistence of very primitive *Streptelasma* characters, to which is added the strong development of tabulæ, the coral in this respect being highly specialized. It is possible that a study of the young will show that this species belongs to the DEUTEROSEPTATA, taking its rank with *Omphima* and *Ptychophyllum*, especially such forms as *Ptychophyllum richthofeni* and *Pt. cyathiformis* of these same rocks.

HORIZON AND LOCALITY: Occurs with the preceding.

Amplexus spinosus de Kon.

var. **sinensis** Grabau (var. nov.)

Plate I, figs. 22a b, 23.

COMPARE:

- 1842 *Amplexus spinosus* de Koninck, Anim. Foss. des Terr. Carb. du Belg. p. 28, Pl. C, fig 1.
- 1852 *Amplexus spinosus* E. & H., British Fossil Corals. p. 176.
- 1872 *Amplexus spinosus* de Koninck. Nouvelle Recherches sur les Anim. Foss. de Terr. Carb. du Belg. p. 75 pl. VI, figs. 6a, b.

1911 *Zaphrentis spinulosa* Frech; Richthofen China, vol V. p. 62, pl. 10 figs. 7a-b.

In the typical form of this species the corallum is elongate, becoming cylindro-turbinate in the mature part, with somewhat twisted form. In the specimen figured by de Koninck in the earlier publication, the entire corallum is armed with scattered spinose epithecal processes, but in the specimen figured in the later work, only the lower half of the corallum, *i.e.* the expanding part, is thus characterized.

In the variety *sinensis* the corallum is slightly curved, and expands more rapidly than in the typical form. In the earlier portion, where the diameter is only about 6 mm., the septa still meet in the center. There are about 22 of them, slightly irregular, and not thickened by secondary deposits. There are a few dissepiments present at this stage. The septal grooves are moderately developed, and the interseptal ridges are rounded. From them arise the scattered spinose epithecal prolongations. These were hollow radiceform expansions, which may have served the purpose of anchorage as in other corals of this type.

The calyx is very deep, and the septal edges are sharp and denticulated. The central flat tabulated area, over which the septa do not extend, occupies a little more than one fourth the diameter of the corallum at that point.

This variety is distinguished chiefly by the smaller size and more rapid expansion of the caliculus, the more numerous septa, which in the typical form are about 16, and the somewhat smaller central non-septate area. The epithecal spines are of the same character as those of the Belgian form.

Length of a specimen about 17 mm. calicinal diameter 11 mm.

HORIZON AND LOCALITY: This variety is represented by two small fragmentary specimens from the Lower Carboniferous (Upper Dinantian) Chihsiashan limestone of Chihsiashan, (Single-tree Hill) Nanking region, province of Kiangsi. They were associated with other corals found in the European Viséan. The species was originally obtained from the Carboniferous limestone of Tournay Belgium, and the Isle of Man.

Frech figured a specimen, without description, from the same horizon and locality, referring it to the American *Zaphrentis spinulosa* Edw. & Haime from the Kaskaskia beds of the Mississippi valley. His specimen is much larger than ours (provided his figures are natural size, no statement to the contrary being made). It is however a more retarded form, being still in the *Streptelasma* stage, with the septa reaching to the center, as in the young of our specimens. The coral can not be referred to *Zaphrentis*, and there is no reason for considering it other than a retarded individual of the above described variety of the European species of *Amplexus*.

Genus **METRIOPHYLLUM** Milne-Edwards & Haime.

(Edwards & Haime, Fossil Corals, p. lxxix, 1850, & Hist. Nat. des Coralliaires, T. III, p. 328, 1860).

This genus was erected by Edwards and Haime for the reception of two European Devonian species *M. bauchardi* E. & H. (*Cyathophyllum mitratum* Michelin) from the Upper Devonian of Ferques, in France, and *M. battersbyi* E. & H. from the Devonian of Torquay in Devonshire, England. A third species was described by Mansuy from south China, and is noted below.

The corallum in this genus is simple, conical or top-shaped, and basally attached. The epitheca is complete. Septa fully developed, not interrupted, slightly warped, and arranged in four groups or bundles. Primary septa presenting a four-armed cross. Dissepiments well developed, simple and more or less horizontal, their arrangement being such that they correspond to one another in position, forming incipient tabulæ.

Edwards and Haime suggested that the quadripartite arrangement of the septa indicated relationship to *Stauria*, where the four primary septa are strongly developed, forming a cross, and that this genus formed a transition type to *Cyathophyllum*. This is an error, due no doubt to the fact that at the time when this was written, the normal quadripartite character of the young of the TETRASEPTATA was unknown. In the light of our present knowledge, we must regard the genus *Metriophyllum* as a persistent primitive form, so far as the septal arrangement is concerned. In other words, the septal grouping has scarcely passed beyond the primitive quadripartite arrangement characteristic of the young of corals of this division, while in other respects the coral has developed, notably in the increase in the number of septa, and the abundant development of dissepiments and their tendency to unite into tabulæ.

The counter quadrants in this genus are accelerated, indicating its relationship to the *Streptelasmaida* from the more primitive members of which this group is derived. The persistence of the pinnate or quadripartite arrangement of the septa is similar to what is seen in the genus *Pinnatophyllum* Grabau* of which *Cyathophyllum scyphus* is the genotype.

That genus forms the most primitive member of the *Cyathophyllida*, being more specialized than *Metriophyllum*, which I would retain among the *Streptelasmaida*. It is not impossible that *Pinnatophyllum* is a derivative of *Metriophyllum*, though I am inclined to think, that these genera represent independent lines of development, one, *Pinnatophyllum* in American, the other *Metriophyllum* in Eurasiatic Devonian waters.

* Devonian Corals of Michigan.

Metriophyllum (?) poshiense Mansuy.

1912 *Metriophyllum poshiense* Mansuy Paléontologie du Yun-nan Oriental; p. 47, Pl. VII, figs. 8a-d.

The corallum is cylindrical and much elongated. Diameter 7 to 8 mm. Epitheca thin, transverse wrinkles not very prominent. There are thirty-six septa, their length very unequal, somewhat sinuous at their inner extremities, and arranged in four groups. The four principal septa extend to the center, but they are not always regularly opposed, two and two. In some individuals one of the primary septa is not more strongly developed than those of the second cycle. The latter are equal in length, while those of the third cycle are somewhat shorter and those of the fourth not over a millimeter in length. (Mansuy).

It is difficult to form a clear conception of the nature of this coral from the illustration given by Mansuy. The cardinal septum appears to be strongly developed, and so are the alar and the counter septa. But there also appear to be other, equally strongly developed septa, in some cases one, in others two additional. This and the general arrangement of the other septa, suggests rather the genus *Pentaphyllum* de Koninck. Again some of the sections suggest *Tachylasma* Grabau. It is evident that a reëxamination of the types is necessary before they can be properly placed. In any case this coral differs so markedly from the European species of *Metriophyllum*, that its reference to that genus seems extremely hazardous.

HORIZON AND LOCALITIES: The specimens described by Mansuy came from the Middle Devonian (Eifelian) between Po-shi and Si-Eul in Yunnan. Deprat also cites it from similar beds at Hoa-Keuou. No other material has been obtained.

Family 3. **CYATHAXONIDÆ** Edwards & Haime (emend. Grabau).

This family at present includes only the genus *Cyathaxonia* Mich. This is a small slender curved conical corallum with rather strong epitheca that does not show the septal grooves, but shows faint growth-wrinkles. The calyx is moderately deep, its sides marked by septal ridges, while its bottom is formed by the septa which meet in the center, joining a cylindrical pseudocolumella which projects in styliiform manner. Inter-septal loculi empty, without dissepiments or tabulae. In the type species *C. cornu* (Michelin), the number of septa is about 36.

The septal development of this species has been studied by Faurot, (1909*) and proves this form to be distinct from that of other known types in the manner of developmental detail. As in the *Streptelasmaida*, the counter quadrants are accelerated over the cardinal, but only to the extent of one septum of each order, there being 4 secondary and 5 tertiary septa in the counter, and 3 secondaries and 4 tertiaries in the cardinal quadrants. The tertiary septa are long, reaching the columella. The early stages



Fig. 67.

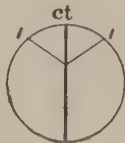


Fig. 68.



Fig. 69.



Fig. 70.

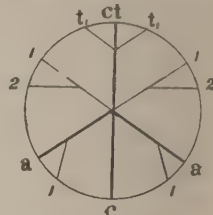


Fig. 71.

Figures 67-71. *Cyathaxonia cornu* (Michelin) a series of cross-sections showing the order of development of the septa (the pseudo-columella is omitted, see text fig. 31). Enlarged. (Modified after Faurot.) c - cardinal, ct - counter, a, a - alar septa; 1; 2; 2; etc. secondary septa in the counter and cardinal quadrants; t, tertiary septa.

however show that the acceleration of the counter quadrants is in reality much more pronounced than is the case in the *Streptelasmaida*, for the first pair of secondary septa appears in the counter quadrants before the alar septa appear. The earliest stage recorded by Faurot, shows a continuous cardino-counter septum crossing the corallum. Then appears the first pair of secondaries next to the counter, after which the alar septa appear near the cardinal.

As these septa develop, their points of junction move along the median cardino-counter septum, until they meet in the center, thus forming six equal septa meeting in the center. After that the septal development is fairly uniform and similar in all the quadrants, except that, as in other accelerated types, the first pair of tertiaries appears next to the counter, along with the second secondary in each quadrant, and the counter quadrants are always one pair of septa ahead of the cardinal. Thus the first pair of secondaries of the cardinal quadrants appears almost simultaneously with the second pair of secondaries, and the first pair of tertiaries, in the counter quadrants. The first pair of secondaries acts as the supporting or guiding septum in the counter quadrants, the succeeding secondaries at first joining it. The same office is performed by the alar septa for the secondaries of the cardinal quadrants. But the most striking feature in the order of development is the close sequence in which the tertiary septa follow the secondaries. Thus in the counter quadrants the first pair of tertiaries developes after the first pair of

secondaries, and on their counter side. The second pair of tertiaries develops after the second pair of secondaries and again on their counter side. The same succession holds for the third and 4th secondaries, and their corresponding tertiaries. Finally the fifth secondary appears next to the alar and is at first joined to the fourth after the manner of the preceding septa. This septum however never attains the strength of the other secondary septa, while the corresponding fifth tertiary does not appear.

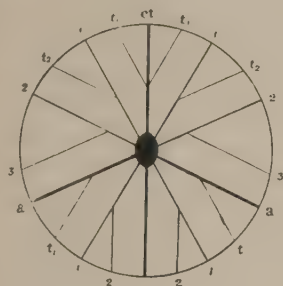


Fig. 72.

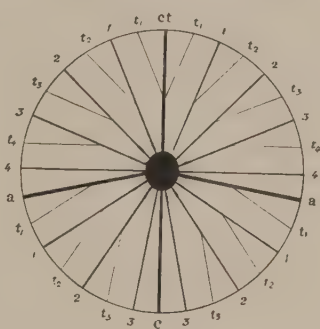


Fig. 73.

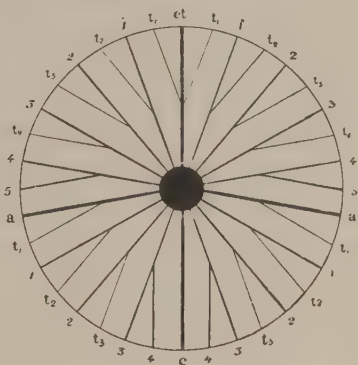


Fig. 74.

Figures 72-74. *Cyathaxonia cornu* (Michelin)—Three consecutive sections of the later stages, showing the order of development of secondary and tertiary septa. Enlarged (Modified after Faurot.) 1-4, and 1-5 secondary septa in the cardinal and counter quadrants respectively; t_1 - t_3 tertiary septa.

In the cardinal quadrants the order of septal development is precisely similar, the first tertiaries appearing after the appearance of the corresponding tertiaries in the counter quadrants, but before the appearance of the second pair of tertiaries in those quadrants. Each pair of tertiaries of the cardinal quadrants appears next after the appearance of the corresponding secondaries, and before the appearance of the next secondary. The tertiaries always appear behind i.e. on the alar side of the corresponding secondaries. The columella is outlined early by a thickening of the central meeting point of the septa. It does not belong to a single septum as in *Lophophyllum*. Some of the stages of development of this coral are shown in text figures 67-74, copied from Faurot's article but with the numbering of the septa changed to bring out more truly their relationship.

CYATHAXONIA occurs in the Carboniferous limestone (Dinantian) of Belgium, England, Ireland and elsewhere in Europe. It has not yet been found in China, but it is not at all unlikely that it will be obtained.



EXPLANATION OF
PLATE I.

PLATE I.

Corals from the Devonian and Carboniferous (Drawn by K. C. Liu 劉光城)

- Fig. 1. *Stereolasma rectum* Hall.....p. 32
 a. Side view of a corallum with upper part cut away; slender species of *Hederella* attached on one side. Natural size.
 b. Section of the same a short distance below the calyx. Twice natural size. Middle Devonian, Tungshan, Kütsing district, Yunnan. V. K. Ting coll. (G. S. Ch. cat. 141)
- Fig. 2. *Tachylasma cha* Grabau.....p. 35
 a. Side view of the holotype natural size.
 b. Section below calyx, enlarged twice. Carboniferous (?) of Yunnan V. K. Ting coll. (G. S. Ch. cat. 142)
- Fig. 3. *Tachylasma aster* Grabau.....p. 38
 a. Polished cross-section near the upper end showing adult characters; enlarged twice.
 b. Section of the same 3.5 mm. lower, showing an earlier stage. This section is reversed with reference to the preceding one. Enlarged twice; Holotype. Black Permian (?) limestone, Changhsing Coal Mine, Chekiang province (Coll. C. C. Liu and J. C. Chao; G. S. Ch. cat. no. 143)
- Fig. 4. *Tachylasma aster* Grabau.....p. 38
 Section of another specimen at an earlier stage, showing characters suggestive of *Tachylasma cha*. In the same rock fragment with the preceding (Fig 3). (G. S. Ch. cat. 144)
- Fig. 5. *Lopholasma carbonaria* Grabau.....p. 43
 a. A specimen with the upper part cut away, showing the strongly curved basal portion; natural size.
 b. Cross-section of the same, enlarged twice. Dark foraminiferal limestone (Lower? Carboniferous); Shih-Lin-Yuan, Kung Hsien, province of Honan. (Coll. C. F. Erickson; G. S. Ch. cat. 145)
- Fig. 6a. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabaup. 51
 Oblique section (reversed) on under side of rock slice. Natural size. The cardino-counter axis lies at an angle of about 30° with the horizontal.
- 6b *Lopholasma carbonaria* Grabau.....p. 43
 Section of a small specimen near the base. (reversed)
- 6c. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabau.....p. 51
 Section of a specimen near the base or initial point (reversed). All natural size

PALÆONTOLOGIA SINICA

Grabau: Palæozoic Corals of China.

Pl.I.



Carboniferous limestone, Tung Chuang, I-Hsien, Shantung province.
(G. S. Ch. cat. no. 146)

- Fig. 7a. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51
Section of specimen 6a, about 3 mm. higher. Upper side of the same rock slice.
This shows normal orientation with counter septum (top) on upper left hand side.
Natural size.
- 7b. *Lopholasma carbonaria* Grabau.....p. 43
Section of the individual shown in 6b., 3 mm. higher; upper side of same slab.
- 7c. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51
Section of the specimen 6c. about 3 mm. higher up (normal). Orientation reverse of
that of the specimen Fig. 7a. the cardinal septum on the left. (See text fig. 61)
- 7d. *Lopholasma carbonaria* Grabau.....p. 43
Section of a very early stage.
- 7e. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51
Part of longitudinal section. (See 8e, 9e.) All natural size, same horizon and locality
as Fig. 6. (G. S. Ch. cat. 146)
- Fig. 8a. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51
Section of outer rim of specimen shown in fig. 7a and 6a, showing some of the septa
of the counter quadrants (reversed).
- 8b. *Lopholasma carbonaria* Grabau.....p. 43
Section of specimen shown in fig. 7c, about 2 mm. higher (reversed) Within the
calyx a section of the smaller end of another individual.
- 8c. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51
Section of specimen shown in fig. 7c, about 2 mm. higher (reversed). The cardinal
septum is on the right. (See text fig. 62)
- 8d. *Lopholasma carbonaria* Grabau.....p. 43
Section of specimen fig. 7d, about 2 mm. higher (reversed) (See text fig. 54)
- 8e. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51
Longitudinal section of a part of a corallum showing the spinous character of the
carinae with their upturned edges shown in transverse section.
- Fig. 9a. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51
Section of part of rim of the specimen shown in 8a, about 3 mm. higher.
- 9b. *Lopholasma carbonaria* Grabau.....p. 43
Section of the small specimen shown in fig 8b, about 3 mm. higher; on upper side
of same rock slice.

- 9c. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabau..... p. 51
Normal view of section of specimen 8c, 3 mm. higher, Cardinal septum on left.
(See text fig. 63)
- 9d. *Lopholasma carbonaria* Grabau.....p. 43
Section of the specimen shown in fig. 8d, on upper side of same rock slice, about
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- 9e. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabau.....p. 51
Another longitudinal section apparently of the same corallum as that figured in
fig. 8e, on the opposite side of the same slab 3 mm. thick, showing carinae in
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- 9f. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabaup. 51
Median longitudinal section of another individual showing horizontal bar-like
character of carinae in section parallel to septum; also showing stereo-columella and
projecting palicolumella. (See text fig. 65) (Figs. 8 & 9, Geol. Surv. China cat. 147)
- Fig. 10c. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabau.....p. 51
Section of the specimen shown in Fig. 9c, about 2 mm. higher (reversed) counter
septum on left. (See text fig. 64).
- 10d. *Lopholasma carbonaria* Grabau.....p. 43
Section of specimen shown in fig. 9d, about 2 mm. higher (reversed). (See
text fig. 56).
- Fig. 11c. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabau.....p. 51
Section of part of calicinal rim of specimen fig. 10c. and about 3 mm. higher on
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pseudocolumella which is free at this point, near the center. (Not well shown.)
- 11d. *Lopholasma carbonaria* Grabau.....p. 43
Section of the specimen shown in fig. 10d, about 3 mm. higher (reversed) on
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All the figures are natural size. Black Carboniferous Poshan limestone, Tung
Chuang, I-Hsien Shantung. (Figs. 10 & 11, Geol. Survey of China, cat. 148).
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- c. Lower end of specimen (polished) showing four strengthened septa at this stage. Enlarged twice.
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a. Side view of de Koninck's type enlarged.

b. Calicynal view of same in further enlargement. Carboniferous limestone of Tournay (Dinantian) (Copies of figures by de Koninck).

Fig. 15. *Lophophyllum pendulum* Grabau.....p. 48

a. Cardinal view of the holotype, natural size.

b. Calicinal view of same, enlarged twice. Carboniferous limestone of Yunnan (?) Geol. Surv. China, cat. no. 150.

Fig. 16. *Lophophyllum pendulum* Grabau.....p. 48

a. Lateral (alar) view, the basal part imperfect; natural size.

b. Calicinal view (cardinal septum on right); enlarged twice. Carboniferous limestone (Dinantian?) Shih-lin Yuan, Kung Hsien, Honan, Coll. C. F. Erickson (G. S. Ch. cat. no. 152).

Fig. 17. *Lophophyllum pendulum* Grabau.....p. 48

a. Lateral view, showing curvature, natural size.

b. Calicinal view, enlarged twice; counter septum near side of greatest curvature. Carboniferous limestone (Dinantian?) Honan. (G. S. Ch. cat. 153).

Fig. 18. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51

a. Side view of a nearly complete specimen polished on the upper surface, and with sides slightly worn. Natural size.

b. Section of the same a short distance below the calyx rim showing free upper end of columella; enlarged twice.

c. A portion of the worn surface of the specimen, enlarged three times, showing the lateral carinae of the septa. Kuantikou limestone, Taiyuanfu district (Loc. 38) Shansi. (E. Norin coll, G. S. Ch. cat. no. 155).

Fig. 19. *Lophophyllum* (*Lophocarinophyllum*) *acanthiseptum* Grabau.....p. 51

Submedian longitudinal section, showing strong development of carinae on lower part of septa.

Kuantikou limestone, Taiyuanfu district (loc. 38) Shansi. (E. Norin coll. G. S. Ch. cat. no. 156).

- Fig. 20. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabau.....p. 51
View of a small specimen with strongly exert columella. Natural size. Hsiehtao limestone, Tungtayao, Taiyuanfu district, Shansi, (loc. 39) (E. Norin coll. G. S. Ch, cat. no. 157).
- Fig. 21. *Lophophyllum (Lophocarinophyllum) acanthiseptum* Grabau.....p. 51
Side view of an unusually long form, incomplete at lower end, and crushed above, showing exert columella. Natural size. Hsiehtao limestone, Tung-ta-yao, Taiyuanfu district, Shansi. (E. Norin coll. G. S. Ch. cat. no. 158).
- Fig. 22. *Amplexus spinosus* var *sinensis* Grabau.....p. 64
a. Side view of a fragmentary corallum attached to rock showing epithecal spines; enlarged twice.
b. Calicinal view of same showing arrangement of septa and flat tabulate floor of calyx. Enlarged twice. Chihsiashan limestone (Lower Carb.), Chihsiashan, Nanking region, Kiangsu. (G. S. Ch. cat. no. 159).
- Fig. 23. *Amplexus spinosus* var *sinensis* Grabau.....p. 64
Another specimen showing septa in broken lower end, broadly expanding form, and epithecal spines. Enlarged twice. Same horizon and locality (cat. 160).

第三次隔壁發生次序、與他屬珊瑚相同。在對邊者每發生於對部、在側邊者每發生於主部。對部第二次隔壁之數每較主部多一、是對部實較主部爲發育。圖中 t_1 t_2 等表明第三次隔壁、1、2 等數表明發生次序。 *Cyathaxonia* 屬爲歐洲下石炭紀 Dinantian 化石、中國尙未發見。

Metriophyllum E and H

單體形如圓錐。隔壁分爲四組，其主要隔壁常在中心成一十字。橫板易誤認爲床板。

Metriophyllum (?) poshiense Mansuy

珊瑚形如圓筒，具有三十六隔壁，皆不等長。最主要之四片，隔壁常達中心，其位置亦無一定。第二次隔壁較短，第三次隔壁尤短。此種珊瑚與歐洲所產者極不相同，或爲異屬化石。載普拉 Deprat 及滿蘇 Mansuy 曾發見於雲南中泥盆紀岩中。（見雲南東部古生物誌 Pale'ontologie du Yunnan Oriental 第四十七頁及第七版第八圖 a 至 d）

第三科 Cyathaxonidae Edwards and Haine (經葛利普修正)

此科現在僅有 *Cyathaxonina* 一屬，形似 *Lophophyllum* 珊瑚。惟其中柱由主要隔壁組成，以相交處爲極厚，是其特徵。（見插圖第三十一）此種發育之情形，可參觀各斷面圖 successive sections。（插圖第六十七至七十四）對部第二次隔壁第一對之發見，每在第一次隔壁完全發見以前，足證此屬發育速度較 *Lophophyllum* 爲尤大。（第六十八圖）是以主要隔壁最初發見多至六片。（第七十圖）其他各隔壁亦次第發生。同時第三次隔壁 t 一對，亦發見於對隔壁之旁。（ct 第七十一圖）始則此種隔壁多與老隔壁相接，繼則其內端因生長線稍轉位置，遂交於中心。發生之次序，雖與 *Streptelasma* 相同，然第三次隔壁發育速度極大。如每對第三次隔壁發生，必在一相當第二次隔壁之後。此與第二次隔壁已近完全發育後第三次隔壁始繼續發生者不同。

此屬主要珊瑚之幼者形似 *Streptelasma* 屬。至長成時，床板發育頗盛，隔壁每不達中心。蓋部中央最平處爲上部床板組成。產四川志留紀岩層中。林德斯傳氏 Lindström 曾研究一種羣體珊瑚曰 *Amplexus viduus*，因立此新屬名 *Synamplexus* 也。下述兩種列入此屬似頗可疑。

Amplexus (?) *distans* Lindström

直圓錐形，自下而上，形狀漸次增大。隔壁尖削甚速，惟近邊處稍灣曲。灰質圓周圍 peripheral ring of stereoplasma 頗窄。隔壁具刺狀物體，橫板顯明。床板極薄，每二十一公厘必有五層。四川東北志留紀岩層中產之。(李希霍勞氏中國譚第四卷第六十三頁及第六版第一圖至第五圖)

Amplexus (?) *appendiculatus* Lindström

此種具有根形外壁苞 proliferations。隔壁較前種爲多，且細長，似達中心。床板較 *A. distans* 尤複雜。產地與前種同。(見李希霍勞中國譚第四卷第六十三頁及第六版第七八兩圖)

Amplexus spinosus de Kon var *sinensis* Grabau (新族)

形小略灣曲。此族初期 early stage 與原初 *Streptelasma* 屬珊瑚相似，但長成時每發生床板，近中心處無隔壁。有橫板，隔壁極少。面上有根形苞。原種產歐洲下石炭紀岩層中。惟此屬形狀極小，蓋部擴張極速，中央無隔壁之面積亦極小，長十七公厘之珊瑚，其蓋之直徑每爲十一公厘，皆此族與原種之異點。江蘇句容棲霞山石灰岩中產之，屬下石炭紀 Dinantian (第一版第二十二圖之 a 及 b 及二十三圖)

lum。隔壁有數脊板、橫板極少。產於河南石炭紀岩層中、或爲太原系之化石。然山西山東之太原系、甚少發見、是以產地終未能確定。又浙江產此種化石一枚、屬二疊石炭紀、(第一版第十五圖之 a b 第十六之 a b 第十七圖之 a b 及插圖第五十七)

Lophocarinophyllum acanthiseptum Grabau (新種)

形細長且彎曲。假中柱非常發育、突出於隔壁之上。隔壁上具有平脊板。(板邊每向上捲曲)此種現象可參觀各種斷面圖、如插圖第六十一至六十三。(第六十二圖與第六十四圖相反)又第六十五縱斷面與 *Lopholasma* (插圖第五十二及五十三)外形極相似。此種初期珊瑚及斷面與 *Lopholasma carbonaria* 尤不易分別。若具有假中柱、則不難分別矣。山東山西太原系岩層中均產之。(第一版第六圖 a c 第七圖 a c 第八圖 a c e 第九圖 a c e f 第十圖 c 第十一圖 c 第十八圖至第二十圖及插圖第五十八圖至第六十五)

Arachnolasma Grabau (新屬)

此屬比前列各屬珊瑚尤大、極似 *Streptelasma* 屬之大者。隔壁及橫板皆極多。假中柱常受壓迫、形如 *Lophophyllum*。惟其四周爲許多大泡沫 cysts 圍繞、是以珊瑚斷面、婉如蜘蛛之網、屬名曰 *Arachnolasma* 意即此。

Arachnolasma sinense (Yabe and Hayasaka)

已發見者、僅此一種。產貴州威寧縣下石炭紀岩層中。第六十六圖爲此種斷面圖。(放大一倍半)
(1920 *Lophophyllum sinense* Y and H 見支那地學調查第六版第二圖 a 至 c)

Amplexus Sowerby

形細長稍彎曲。此種珊瑚之各橫斷面，所以表明隔壁發育之次序，見第七圖d至第十一圖d各圖。又插圖第五十四至第五十六爲其中三圖之放大形。第五十四圖（下面）及第五十六圖與第五十五圖（上面）相反。長成之珊瑚，每發生內溝，無中柱。（插圖第五十六及第一版第十二圖）

此種爲山西太原系之普通化石，每發見於山西太原縣關底溝石灰岩中，河南山東亦產之，均屬下石炭紀上部。（第一版第五圖之a b 第七圖之d 至第十一圖之d 第十二圖及插圖第五十四至第五十六）

Lophophyllum E and H 及 *Lophocarinophyllum* Grabau 新屬

形小而細長，假中柱發育特甚，由對隔壁之內端變厚而成。*Lophophyllum* 屬之主要珊瑚，當初期時其中柱每與對隔壁相離，他屬之中柱則反是。

Lophocarinophyllum 與 *Lophophyllum* 之異點，前者具有平脊板（板邊每向上捲曲）恰如 *Lopholasma*。插圖第六十五及五十二之比較，即所以表明 *Lophocarinophyllum* 屬之幼者與 *Lopholasma* 極相同。然此屬之老者，每發生假中柱，且極明顯，其分別自易明矣。

Lophophyllum proliferum (Mc Chesney)

此爲北美普通化石之一種，亦產於中國江西樂平二疊石炭紀岩層中。曾經克綏爾氏 (Kaiser) 研究。（參觀李希霍芬中國譚第四部第一百九十四頁及第二十九版第七至第十各圖）中國他處尙未有發見者。

Lophophyllum pendulum Grabau (新種)

此種之特徵，在假中柱與細長對隔壁相結處特別漲大。自上面觀之，宛如古式鐘之擺錘，故種名曰擺 *pendu-*

Tachylasma aster Grabau (新種)

形細長、隔壁最厚者有四片。迨長成時、其每一主部之兩片隔壁每一對部之四片隔壁(第三圖)及一對隔壁常繼續增厚(對部隔壁總數爲十一)交於中心而成星形。(種名即取此意)珊瑚幼部斷面 younger sections (第二圖之 a 及第四圖)隔壁增厚者極少。此種最新發生之隔壁亦如 *T. cha* 一種、蓋由 *T. cha* 進化而來者。此種最初階級 earliest stage 之性質與 *Streptelasma* 相似、見插圖第五十一(第四十一頁)浙江長興煤系石灰岩中產之、似屬二疊紀(第一版第三圖之 a b 及第四圖)

Heterelasma Grabau (新屬)

此屬以具有四假內溝爲其特徵。對隔壁頗短成對內溝。已發見者僅 *Heterelasma edwardianum* (de Koninck) 一種。第一版第十四圖之 a 爲其放大形。第十四圖之 b 爲其鑿之特別放大形。產於歐洲石灰紀岩層中、中國從未發見(第一版第十四圖之 a 及 b)

Lopholasma Simpson

此屬與前列各屬迥異、具有灰質中柱 *Stereocolumella*、但未達臺部、是其特徵。又隔壁兩旁具有平脊板。(亦有向上捲曲者)脊板方向視斷面方向而異。其向上捲曲之部有似補隔壁 supplementary septa 者。(正橫斷面)有似隔壁之分支者。(稍斜斷面)有成鈎形者。(斜斷面)插圖第五十二及第五十三爲一種泥盆紀此屬化石之縱斷面。泥盆石灰兩紀均有之。

Lopholasma carbonaria Grabau (新種)

中國各屬及各種珊瑚

Stereolasma Simpson

此屬長成之珊瑚，其隔壁成放射狀，真內溝亦頗發育，橫板極普通，但無床板與脊板。灰質中柱 *Stereocolumella* 最發育，但不達萼部 *calyx*。發育情形可參觀此種珊瑚放大斷面圖（第三十頁插圖第二十七至四十七）

Stereolasma rectum (Hall)

中國僅發見一枚，產雲南泥盆紀岩層中。第一版第一圖之 a 表明此種化石之形狀及性質，第一圖之 b 爲其二倍放大斷面圖。

Tachylasma Grabau (新屬)

此屬與前屬迥異，具有側隔壁及對部最初兩片第二隔壁。此種隔壁下部極厚，上部常突出於萼口，爲此屬發育特速之明証。tachygenetic 意即加速，故此屬定名爲 *Tachylasma*，且爲中國之特產。

Tachylasma cha Grabau (新種)

此種形似 *Stereolasma rectum*，隔壁厚度極有規則，形如叉字，種名曰 *cha*，即取此意。橫板極少。中國石炭紀岩層中產之。（第一版第二圖之 a b 及插圖第五十）

Tachylasma elongata Grabau (新種)

形細長。惟此種長成珊瑚 *adult* 之隔壁，不似前一種之厚。曾發見於江西豐城石炭紀岩層中。（第一版第十三圖之 a b 及 c）

珊瑚各論 科 屬 種

第一科 *Petrariae de Koninck* (經葛利普修正)

單體珊瑚構造之最簡單者、每具有外壁及脊狀之短隔壁。即此科之最發育者、其隔壁亦鮮達中心。故此類長成珊瑚之現象、即他類珊瑚幼時之現象。如 *Petraria* 初期數種珊瑚 *early species* 常爲他種四射珊瑚之祖先。

此科珊瑚分爲下列兩屬。

1 *Petraria Münster* 奧陶紀至石炭紀

2 *Polycocelia King* 1 疊紀

古生代末期之各種珊瑚、多具有各種原始性質。上列兩屬、中國尙未發見。

第二科 *Streptelasmaide Grabau* (經修正)

珊瑚種類不一、常由低級漸至高級。始則多無隔壁、繼則雖有而不相交、吾人謂之 *Petraria* 階級、終則各隔壁互交於中心。大抵低級珊瑚、其隔壁每爲四分式排列 *quadrupartite*。假內溝 *pseudofossule* 亦因之而生。(第十三頁插圖第二十一) 最高級珊瑚則不然、其隔壁每爲放射狀、常因延長而扭交於中心。脊板 *carinae* 普遍。珊瑚常有之。內溝僅階級最高之珊瑚 *specialized types* 有之。假中柱由石灰質組成者、如 *Lopholasma* 及 *Stereolasma* 等是。假中柱或爲粗棒狀者、如 *Lophophyllum* 等是。無床板、惟最高級之 *Amplexus* 屬有之。橫板 *dissepiments* 極少、有時不見。對部第二隔壁之數常較主部爲多。此科各屬詳載英文論文中。(第五頁)

種名。而此種之性質、必爲羣體中各個體所公有。羣體珊瑚發生之加速度與遲緩度、既已了解、則各種複雜珊瑚之解釋皆可迎刃而解矣。

然發育之所以遲緩者、亦有因生物一部分遇損傷而然者、（屬病理學）全與羣體無關。例如羣體之芽因壓迫而損傷、餘皆甚發育、且爲圓柱狀。圓柱狀爲羣體中母個體 *parent corallite* 之特別標記。如生長過密、則珊瑚各個體常爲多角形、屬此者爲 *Lichostrotion*, *Prismatophyllum* 等屬。

生物常因環境之關係而受損傷、則發育亦遲緩。然有一部分因之而反發育者、此蓋絕無而僅有者矣。各論中之原理、僅指保存完全之標本而言。然亦有數類化石之個體、顯有發育之階級、雖可用以解釋、然最後之決定、非深明每種之發生學不可也。

各種珊瑚之圖、其位置皆固定、對隔壁在上、主隔壁在下、上兩部爲左右兩對部、下兩部爲左右兩主部。

化、故每成爲加速變種 *Mutations*。若發育極緩之個體、則謂之遲緩進化。此種生物雖至長成時期、仍具幼年性質、亦常成爲遲緩變種。加速度 *acceleration* 與遲緩度 *retardation* 有時影響于生物全個體、有時僅及於一部分。(即不等加速度及遲緩度)蓋一種珊瑚常有某部發達頗速而他部分則遲緩者。此種情形易發生一種新譜系。如某種珊瑚、其內溝已發達、而其隔壁仍爲第一次四射式階級、甚至脊板亦發生於退化隔壁之上、屬此者爲 *Pinnatophyllum scyphus* 及 *P. scyphus* var *carinata*。他如同一祖先之珊瑚、其隔壁發達已由四射式 *tetrameral* 變爲輻射式 *radial*、但無內溝及脊板、如 *Ocyathophyllum* 屬是。亦有脊板在幼時已發達、其隔壁亦爲輻射式、但內溝多不發育、(亦有例外者)如 *Heliophyllum* 屬是。故欲研究生物個體、不可不知其進化之程序、而其進化之程序、非研究形態學不爲功。

生物進化之加速與遲緩、或受環境之影響、或可歸於遺傳性之解釋。

羣體珊瑚中進化之加速度及遲緩度

羣體珊瑚爲各個體結合而成、其中發育特著者有之、生長遲緩者亦有之、即如 *Philipsastrea* 珊瑚、其個體中之牆已損壞、隔壁常向外伸出、而與隣近之隔壁相連接。然亦有珊瑚各個體之牆、仍完全保存者。是則此羣體珊瑚中已具有兩種性質。

羣體珊瑚常保存其祖先性質、與 *Philipsastrea* 屬極相似、(牆甚顯明)有數個因體進化而隔壁伸出、同時珊瑚之牆亦因擁擠而損壞。又如 *Lithostrotion* 珊瑚之個體、其中柱應非常發達、然因退化而顯祖先之 *cyathophylloid* 階級者、如 *L. kaipingense* 一種。此類羣體珊瑚顯似有兩屬珊瑚性質、然尋常鑒定化石、僅用一

羣體珊瑚之生成

四射珊瑚中之羣體珊瑚，其各個體係從母體發生，此種產生法謂之分芽法 *budding*。芽苞發生太多，偕母體繼續生長，故羣體珊瑚之個體 *corallites* 亦多，且相連接。蓋珊瑚生長密，珊瑚虫常爲多角形，故珊瑚之橫切面，亦爲多角形。各個體之牆壁或連續或分離，視其發生之情形而異。設僅有一芽從母體發生，且與母體同時生長。此種個體之組織極疎鬆，且不相連接，其切面每爲圓形。

分裂法 *division* 四射珊瑚最爲常見，四射珊瑚則極稀。兩盃中間之分芽法 *intercalicinal budding* 亦如是，其新芽係從珊瑚個體相連處 *extrathecal portion* 發生，亦即珊瑚虫連續之處。四射珊瑚之新個體，常由卵發生，然與母體毫無關係。

個體進化論或發生學

珊瑚虫之發生學 *Ontogeny*，雖與環境有關，然實根據於生物之遺傳性 *heredity*。珊瑚堅部之有各種體形階級 *morphic stages*，所以表明珊瑚虫進化之次序，欲研究此種進化程序，可先研究珊瑚之各種切面，以珊瑚幼時之性質爲最詳故也。近時依此方法研究者，僅有數類。大半各屬之關係及各種各屬之性質，仍根據於長成珊瑚之性質，實非正當方法。設期學有進步，非將每屬珊瑚最要各種珊瑚之切面，詳細觀察不可也。

加速度與遲緩度

珊瑚個體生長時，其一部生長之遲速率或異。大抵某種珊瑚之各個體有一定產地，故其生長率常不變。有時某處所產之某種珊瑚，生長極速，雖未至成年時期，其各種性質，已與長成者無異，此個體之進化，謂之速進加

之、如始新統之 *Turbinolia* 等是其構造簡單、間有複雜者、或爲堅固物質、或爲疎鬆物質、其爲珊瑚虫最初分泌之物質則一也。四射珊瑚之中柱、其結構非原始的、實乃次生的 *secondary*。質言之、即此種中柱、僅長成之珊瑚有之。其各隔壁相交處厚度特增、故成中柱。有主隔壁與對隔壁相交而成者、如 *Cyathoxonia* 是。（如第三十一圖）有各種隔壁相交而成者、如 *Lithostroton* 是。（如第三十二圖）有因對隔壁末端厚度特別增加而成者、如下石炭紀之 *Lophophyllum* 是。（如第三十三圖及第一版第十五圖之 b）有因對隔壁之末端 *inner ends* 分開而成者、如 *Lophophyllum proliferum* 一種是。（如第三十四圖）四射珊瑚之各類中柱、其形狀極似圓柱、乃從萼底發生者也。

假中柱 *pseudocolumella* 亦可分爲數類、

中柱由近中心處之各隔壁末端互紐而成者、謂之互紐中柱 *streptocolumella*。如 *Streptelasma* 及 *Clisiophyllum* 等屬是。亦有長成之珊瑚、其中心因骨質或灰質之沈澱而成者。前者物質疎鬆、謂之骨質中柱 *sclero-columnella*。如 *Enterolasma*（如三十五圖）屬之。後者物質堅固、謂之灰質中柱 *stereo-columnella*。如 *Stereolasma* 屬（第二十六圖）及 *Lopholasma*（如第五十一圖）等是。有時中柱亦爲床板所組成、形如圓錐、謂之頂生中柱 *Acrocolumella*。如 *Acrophyllum* 是。亦有中軸特別發育者、如 *Lithostroton* (*typical*) 屬是。

有時珊瑚之盃、其突起部分完全以泡沫組成者、謂之泡沫中柱 *cystocolumella*。如 *Heliophyllum* 數種及其他各屬等是。最複雜之中柱、乃集合上列數種組織而成、如 *Lonsdaleia* 及其他各屬等是。世之鑒定化石者、欲診斷其爲何屬、則中柱之分類似不可不察也。

(間亦有達床板之上面者)爲其特徵。

此種內牆、亦可稱之爲孟壁、*cyathotheca* 因如倒置各孟相疊而成。設珊瑚外隔壁帶 *outer septal zone* 損壞、則成有槽之圓柱體、如第三十圖。

四射珊瑚之內牆、至少可分爲四類、

一 眞內牆或葉壁、爲隔壁所組成、其隔壁常灣曲成直角、且互相連接。具此者爲 *Crepidophyllum* 及 *Eridophyllum* 兩屬。

二 橫板壁或骨質壁、爲一排或數排之橫板所組成。具此者爲 *Acervularia*、*Diplophyllum* 及 *Lithostrotion* 等屬。

三 灰質壁由動物分泌石灰質而成。此處隔壁特別發育。具此者爲 *Prismatophyllum*、*Phillipsastrea* 及 *Pachyphyllum* 等屬。

四 床板內牆或孟壁、爲床板所組成。其床板常向下灣曲、如各孟倒置於床板上。具此者爲 *Depasophyllum* 及 *Diphyphyllum* 兩屬。

上列四類內牆、除第一類爲眞內牆 *holendotheca* 外、餘均爲假內牆 *pseudendotheca*。第一類之隔壁常不通過內牆、第二及第三兩類之隔壁常通過內牆、第四類之隔壁亦恆不通過、間亦有達床板上面者。

中柱及假中柱

眞中柱 *true columella* 爲珊瑚中心突起之部分。形如尖柱、自孟部 *thecarium* 之底直達萼口、惟六射珊瑚有

diphyllum 相同、及至長成、內牆益發育、其裂口因以閉塞、如第二十六圖。凡此種長成之珊瑚、其第一次及第二次隔壁常向內部四射、且與內牆相連、然決不越過。其內牆之內部、常爲床板所填充。第三次隔壁多不與內牆相接。總之長成之珊瑚、其完全內牆常爲管狀、隔壁不能穿入。且此種真內牆完全爲隔壁所造成、故可稱之爲葉壁 *phyllotheca*。

(二) 內牆亦有以橫板 *dissepiments* 組成者。其至中心及邊爲等距離。但此非真內牆、因其隔壁（第一次及第二次）每穿入而達中心、如第二十七圖。此種假內牆謂之骨質壁 *sclerotheca*。其與隔壁之相互關係、極似六射珊瑚。惟六射珊瑚之隔壁常向外伸出（其伸出之部分謂之外隔壁 *costae*）爲其異耳。總之此種假內牆爲骨質 *sclerites* 所組成、完全與隔壁無關、如 *Diphyllum Lithostrotion* 及 *Acervularia* 等屬有之。

(三) 珊瑚近中心處之隔壁、厚度驟增、且互相連絡、如此者亦謂之假內牆、如第二十八圖。此種假內牆與葉壁及橫板壁極易分別、因此爲石灰質 *stereoplasm* 所成、故亦謂之灰質壁 *stereotheca*。歐美泥盆紀 *Pinnatophyllum* 屬之各種、歐洲上泥盆紀之 *Phillipsastrea* 屬皆有之、尤以 *Pachyphyllum* 屬爲最著。此種內牆之地位與珊瑚盃形極有關係、最普通者其萼 *calyx* 之四邊極平、內部恆凹。即具橫板壁之 *Acervularia* 屬亦有此現象。

(四) 第四類之內牆、與前三類迥異。其具此者泥盆紀則有 *DePasophyllum* 屬、下石炭紀 *Dinanian* 則有 *Diphyphyllum concinnum* 種。此種內牆爲床板所組成、其四邊常向下灣曲、婉如盒蓋、且層層相疊、如第二十九及第三十兩圖。極與葉壁 *phyllotheca* 相似、惟常爲葉朵狀 *scalloped* 形如海扇、其隔壁從未穿過內牆、

tion 屬是。

泡沫組織

泡沫組織 *cystose structure* 珊瑚各屬均有之。有僅限於盃部一部分者、有完全以此填充者。當盃部完全爲此物質充滿時、其隔壁常顯於上面、卽知泡沫 *cysts* 實先隔壁而發生、如 *Microplasma* 是有時發生於隔壁之間、後漸全變爲此種組織、如 *Actinocystis* 是有發生於外部 *outer zone* 者、如 *Endophyllum* 及 *Lonsdaleia* 等是。亦有發生於內部 *inner zone* 者、如 *Mesophyllum* 是。泡沫爲珊瑚虫分泌之物質、上部常隆起、爲當日生物軟部收縮之一證、其組織多且細、間亦有較粗者。有時外部粗泡沫部與外壁同受侵蝕、完全毀壞、故珊瑚外部、形極粗糙、如 *Biothrophyllum* 是。

內牆

內牆 *inner wall* 因其組織之不同、可分四類、茲先就論每類組織之大概、再述分類之結果、

(一) 安特生君 G. E. Andersson 曾研究珊瑚薄片、發明 *Crepidophyllum* 及 *Eridophyllum* 兩屬真內牆之由來、其隔壁常排列成爲四分式隔壁組 *quadripartite*、至長成時、後生隔壁之末端 *inner ends* 常灣曲成直角、以與第一次隔壁相連、如二十四圖。對部各隔壁、其末端常從兩邊向對隔壁灣曲、且互相連接而成內牆。主部之各隔壁、則向兩邊之側隔壁灣曲、亦連接成內牆。故內牆共有三裂口 *seams*。其在兩邊者爲側假內溝 *alar pseudo-fossula*、其主部者爲主內溝 *cardinal fossula*。兩邊之裂口常、有橫板經過其上。*Crepidophyllum* 屬之主部裂口常開、故內牆開口處、亦在主部、形如馬蹄。*Eridophyllum* 屬則不然、其幼時之內牆、雖與 *Crepid-*

邊向上灣曲、自斜斷面觀之、極似灣鈎。(第一版第九圖之d)橫斷面有時截脊板之上部、脊板則爲隔壁之附壁、婉如雙隔壁焉。(如第一版第五圖之b)

橫板及泡沫板

橫板 *dissepiments* 爲隔壁間之平板、斜置底部、上部略凹。骨質物常從中間插入且與隔壁相連結、如第二十二圖。(見第十六頁)近中心處之橫板、常輾合成爲床板或爲床板面積 *tabulate area*。有時此板互相連接成爲骨質壁 *sclerotheca*、極似內牆。然究與內牆有別、蓋隔壁常越之而穿入中心故也。

泡沫板 *cystosepiments* 亦爲隔壁間之板、爲泡沫物質所組成。上部凸起、爲動物軟體收縮及灰質沈澱之一證。泡沫板發育完全、與橫板極易分別。惟有時漸變爲橫板、無判然之界限。

床板

床板 *tabulae* 爲珊瑚中心之平面板、四周之床板常變爲橫板。有時床板僅發生於內壁以內、珊瑚之四周、悉爲泡沫組織。間亦有床板完全經過盃部者。床板所以表明珊瑚盃部及隔壁之進化。珊瑚之幼者、常無床板、惟長成者有之。又原初珊瑚亦無床板、即其長成者、床板亦不多。例如 *Zaphrentis* 之標式化石 *typical form* 常無床板、然此屬之長成者、亦常有一床板。發達較完全之 *Heterophrentis* 屬、亦常有之、初發見之床板、相隔頗遠、後發生者則較密耳。他如發達最完全之 *Caninia* 及古生代後期各屬珊瑚、其床板極多、層層相疊。可知愈發育者則其床板愈多。床板發生愈速、則愈不完全、中心僅有一部分與已成之床板相結合。有因中心突起爲旅棚狀者、如 *Acrophylum* 屬是。因灣曲爲螺狀者、如 *onsdaleia* 屬是。有中心突起爲柱狀者、如 *Lithostro-*

泥盆紀之 *Mesophyllum* 屬其盃部中心常爲泡沫組織 cystose structure。有時盃部四周之隔壁極不顯明，且爲泡沫狀，然其幼者，隔壁常達盃部之四周。（見珊瑚下部之橫斷面）如單體珊瑚之 *Endophyllum*、羣體珊瑚之 *Spongophyllum* 皆是。他如石炭紀之 *Lithostrotionella* 及 *Lonsdaleia* 亦有此種性質。蓋此屬生物，係由隔壁發育之各屬進化而來也。

脊板

脊板 *carinae* 爲隔壁兩旁之板片，常與隔壁相連。其位置或直立或斜置（對於盃之平面而言）自橫斷面觀之，此板宛如隔壁中間之橫壁 *cross bar*，爲泥盆紀 *Helioophyllum* 屬化石之特徵。（如第二十二圖）然其幼者，常不顯露。脊板之多少，常與此屬珊瑚生成之年代爲比例。脊板發育緩則發現遲，即長成之珊瑚，其脊板亦不多。反之發育速，則發現早，長成之珊瑚，其脊板亦多。各類生物進化速度之比較，皆可於長成珊瑚脊板之多少定之。脊板與前所論之內溝均無與于各屬相互之關係，僅足以表明各屬進化之階級而已。凡具脊板者，不必爲 *Helioophyllum*，即 *Zaphrentis*（原屬 *genotype*）亦有之。

脊板有時發育不著，僅長成之珊瑚有之。如泥盆紀 *Pinnatophyllum scyphus* 種之 *carinata* 一族是。有時有某屬數種中一種，具此性質，如泥盆紀之 *Zaprentis cornicula* 是。有時各種皆然，而爲某屬之特別標記者，如 *Helioophyllum* 屬（*Cyathophyllum* 變屬）

脊板之位置，亦有平鋪者。常發生於隔壁之兩旁，且不對稱，縱斷面及斜斷面均足以表明此種現象。如 *Lopholasma* 及 *Lophocarinophyllum* 兩屬，見第五十四至六十二各圖及第一版第六至第十一各圖。有時脊板外

部第二次隔壁之一對、常特別加厚、爲其特徵。(第五十圖及第一版第二圖之b、第三圖之a、b、第四圖第十三圖之b)

最可注意者、隔壁之厚度常限于最老部分、(即珊瑚底部)不顯露于莖上、然最厚之隔壁、亦常發見。

幼珊瑚虫之外層、常爲摺疊狀、故此處石灰細胞、非常活潑。隔壁分內外兩層、皆于中心相交、隔壁增長愈大、外部石灰質之加入亦愈多、因之內外層亦極顯明。有時珊瑚外層變爲矽質、其內層仍爲灰質、故易溶解。隔壁之外端常與外隔壁溝相對、外隔溝中間爲外壁、常向外突起、外壁有時因骨質加入而益厚、且與隔壁兩邊之各骨質層 *sclerenchyma* 相連絡、否則側邊各層、仍分開爲橫葉 *dissepiments*。(如第二十二圖)

隔壁長度之變遷

隔壁生長愈速、其長度愈增、有時因擁擠而灣曲。如擁擠過甚、中心成柱狀物體、名爲灰質中柱 *streptocolumella*。此以 *Clisiophyllum* 屬爲最顯著、*Cyathophylloids* 次之、所以表明隔壁發育之程度也。

反之隔壁極短、無論老幼、悉不于中心相交。有時原初珊瑚之老者、近中心處常爲床板填充、隔壁長至中心即止、且不相交、此爲隔壁末端發育停滯之證。此種現象以 *Amplexus* 屬珊瑚爲最著。他類亦有之、但不明顯。如 *Streptelasma* 科中之各珊瑚、在泥盆紀即如此、但極盛時期爲下石炭紀 *Dinantian*、如 *Amplexus* 屬珊瑚是也。他如 *Zaphrentis* 科則有 *Siphonophrentis* (中泥盆紀) *Ganinia* 及 *Siphonophyllia* (下石炭紀) 等屬、*Cyathophyllidae* 科則有 *Campophyllum* 等屬、皆具此種性質。此乃表明生物發育之程序。而各屬之具此性質者、可謂爲發育之平衡 *parallelism in development*。然與各屬相互之關係無涉。

內溝爲珊瑚之特別標記、既如上述。茲就生物譜系論之、內溝有發生早者、有發生遲者。大抵具有內溝之各種珊瑚、較無內溝者爲進化、而內溝發生較早之各種珊瑚、較發生遲者亦爲進化。又如同屬之兩種珊瑚、其一已至長成時期、內溝尙未發達、其一發育頗甚、且後者之地質年代較前者爲古、前類珊瑚卽不當與後者同屬一系、而別爲退化之一分支 *retarded lateral branch*。又有兩種珊瑚、其一內溝在生物長成時始發達、其一在幼年已完全發達、至長成時常發生漏斗狀內溝、此兩種亦不可歸爲同屬。例如 *Caninia* 屬珊瑚、至長成時內溝始發現、而 *Siphonophyllia* 一屬、先經過 *Caninia* 階級、至長成時、常發生漏斗狀內溝。*Siphonophyllia* 屬之幼者、易誤認爲 *Caninia*、若能識別其幼稚之性質、卽易識別矣。各類珊瑚之內溝、以 *Zaphrentis* 屬爲最發達。吾人應知者、內溝乃表明生物進化之階級、無與於各屬相互之關係也。

隔壁之厚度

四射珊瑚之隔壁、常因石灰質 *stereoplasm* 之加入而益厚、其形如楔、中心最薄、近邊漸厚、至各隔壁相接爲止。有時僅一對隔壁加厚、餘均仍舊、屬此者爲 *Pinnatophyllum noroni* 一種、其主部隔壁特別發育。此或由珊瑚受侵蝕時、惟主部保存較爲完全。有時各隔壁爲石灰質填充、愈形堅固。有時石灰質之厚度、僅限於一部分、如 *Pinnatophyllum* (*Heterocaninia*) *tholusitabulatum* (Yabe and Hayasaka) 是。此種隔壁之最厚處、常近四周、近中心處則愈薄。此種化石之外邊、在未埋沒以前、常有侵蝕痕跡、不若內部之堅固。

隔壁最厚處、亦有時在近中心處、形如內牆 *inner wall*、惟隔壁仍向內伸入、不若內牆之有規則、此種組織謂之灰質牆 *stereotheca*。以中國所產之 *Tachyasma* 屬珊瑚（共三種）爲最著。此種原初珊瑚之側隔壁及對

射珊瑚之幼者多有之、其地位常在近側隔壁處之對邊、所以表明各個體進化之階級。若長成之珊瑚、仍具此現象、則爲退化矣。如第一版第十四圖之^b。

主假內溝 *cardinal pseudo-fossula* 亦所以表明進化中之各階級。若長成 *adult* 之珊瑚仍具此溝、或其側近第二次隔壁仍爲羽狀、皆所以證明生物之退化。如 *Aulacophyllum* 及 *Pinnatophyllum* 等屬皆是。主面積爲發育最盛之處、兩主裂口 *cardinal gaps* 常因主隔壁之損壞、合一而爲真內溝 *true fossula*。

內溝之意義

內溝由於主隔壁毀壞而成。如主隔壁發生於珊瑚最大灣曲處側近 *side of greatest curvature*、則關生物個體之病理學、若發生於凹邊、即爲衰老之明證。大抵長成之珊瑚、其主隔壁爲第一次隔壁中最先發生者。即不然、亦可謂生物發育初期中一緊要構造也。多數珊瑚、由幼而老、其主隔壁皆甚發育、然亦有一種珊瑚、當幼稚時、其主隔壁非常發達、至末期、即衰萎、是以內溝之發生時期、僅限於各種生物（或數種生物之變種）衰老時期。質言之、內溝爲珊瑚緊要構造之一、常發生於生物末期。然亦有生物譜系中之初期珊瑚、多無內溝、惟末期之衰老者、乃大顯著如 *Streptelasmaidae* 屬珊瑚之內溝、在泥盆紀以前、率未之見、至泥盆紀時、此屬之最發育者、始具內溝。又如 *Zaphrentidae* 屬珊瑚、在幼稚時、其內溝已發生。然則內溝爲珊瑚譜系各屬末期之一緊要構造已無疑義。又如大圓柱狀珊瑚之具床板者、常因之而成漏斗狀內溝 *siphonofossula*、屬於此者爲 *Siphonophrentis* 及 *Siphonophyllia* 兩類珊瑚。此類特別組織常與珊瑚虫軟體之構造極有關係、不可不察焉。

與主隔壁相近、故對部常較主部爲大。其第二次隔壁、亦先發現於對部、如第十六圖。雖亦有數類珊瑚之主部、因發育特甚、故較大、然第二次隔壁是否先在此主部發現、尙屬疑問。欲解決此問題、非研究此類珊瑚之幼小者不可。

第二次隔壁之第一對、常發見於對部、第二對則發見於側隔壁及第一對隔壁之間。質言之、即對部近側隔壁處爲發育最速部分、發育愈速、則此部繼續增大、新隔壁亦即隨之發生、如第十七圖。此種新隔壁、常與側隔壁排成羽狀 *pinnate*、其發生之地位、次第增高、觀外部外隔壁溝 *costal grooves*、即可知其排列之情形矣、如第十九圖及第一版第二圖之 *a*。第十四圖之 *a*。設對部發育特甚、則第三次隔壁之發現、常在第二次隔壁未完全發育以前。（第十八圖）近對部兩邊所發現之隔壁、每爲第二次隔壁、如 *Cyathaxonia* 屬珊瑚之第二次隔壁、常與第三次隔壁輪流發生。即每一對第三次隔壁發生、必在相對之第二次隔壁之後、此種隔壁在對邊者 *counter side* 每發生於對部、在側邊者、發生於主部。此種現象、將於此屬各論中詳言之。

主部之近主隔壁處、爲隔壁最先發生處、發育頗速、新隔壁常繼續加入。（如第十七十八兩圖）惟近側隔壁處則反是、生長極緩、其第二次隔壁幾與側隔壁平行、第三次隔壁間亦發生、新隔壁之位置繼續增高、且與主隔壁排成羽狀。此種現象、各種原初珊瑚之隔壁溝表明最顯。（如第二十圖及第一版第十五圖之 *a*）

珊瑚有四處、最爲發育、即對邊近側隔壁及主隔壁之兩旁、新隔壁常與舊隔壁相交、有時一象限 *quadrant* 之各隔壁、常如是相交、成爲四分式隔壁組 *quadrupartite septal grouping*、如第二十一圖。所生之裂口爲生長最發育之處、且有無第二次隔壁及橫板 *dissepiments* 插入、名曰側假內溝 *alar pseudo-fossule*。此種現象四

隔壁溝

珊瑚盃部之外壁、因厚薄不同、面上常有縱溝、縱溝內部爲隔壁、即每一隔壁面必對一縱溝、故名曰隔壁溝。單體珊瑚兩隔壁間之外壁、常向外突出、有時誤認爲外隔壁 *costae*。外隔壁爲隔壁之向外延長部分、以六射珊瑚爲最顯著。(如第十一圖之 *b*) 四射珊瑚盃部外邊之縱溝、亦可稱之爲外隔壁溝 *costal grooves*。(如第十一圖之 *a*)

隔壁之生成

四射珊瑚之隔壁、就其發生之次序、常得分爲第一次 *primary* 第二次 *secondary* 第三次 *tertiary* 等隔壁。珊瑚長成時、其第一次隔壁與第二次隔壁極相似、亦可總稱之爲第一次隔壁、第三次隔壁當爲第二次隔壁。

第一次隔壁包括主隔壁 *cardinal septum* 對隔壁 *counter septum* 及側隔壁 *alar septa*。第一次隔壁有時生長極速、故各隔壁同時發生。(如第十二圖) 有時主隔壁及對隔壁最先發生、分盃部爲相等左右兩部。(如第十三圖) 原初珊瑚隔壁初生、漸次長大、終即交於中心。惟發育特甚之珊瑚、其主對兩隔壁發生後即相交。側隔壁發見、似分盃部爲四部、上兩部爲主部 *cardinal quadrants*、下兩部爲對部 *counter quadrants*。(如第十五圖)

古生代有數類珊瑚、其側隔壁發生地位與主隔壁及對隔壁之距離常相等、故各部亦相等。然大半側隔壁多

者、始能生活於流水中、否則只在靜水中耳。

珊瑚盃部生長時、常於側旁發生根形苞 *root-like proliferations* (第一版第二十二、二十三兩圖) 漸由空管變爲堅固。當珊瑚生長時、新苞猶存在、至珊瑚末期、狀如外壁之底部擴張 *basal extensions*。

根形苞爲珊瑚各譜系之特別標記。然各類珊瑚之相互關係、尙難由此斷定。蓋同屬各種珊瑚、有具根形苞者、亦有不然者。如 *Amplexus* 屬珊瑚中、僅 *Amplexus spinosus* (第一版第二十三圖) 一種具有根形苞。有時損壞遺失、惟外壁面上顯有節瘤 *node*、以明其所存在者。如 *Rhizophyllum* 及 *Omphima* 兩屬是。結瘤之顯著與否、以發育之程度爲斷。

羣體珊瑚之外壁

羣體四射珊瑚中其母體 *mother corallite* 萼邊、常發生新芽 *bud*。設珊瑚爲疎鬆物質、則外壁之重要亦如

單體珊瑚。然有時因珊瑚虫擴張常發芽苞、以連合各個體、使變爲堅固、後因珊瑚虫收縮、石灰物質仍繼續分泌、故芽苞常著其旁。 (*Eridophyllum*)

羣體珊瑚生長頗密、則各個體因擁擠而變爲多角形 *prismatic*、其盃部邊上常因主要隔壁位置之更迭、以致外壁(兩層)變爲多曲形、如第十圖。

有時羣體珊瑚外壁全失、因隔壁生長速度驟增、致各個體之隔壁互相連絡、此種現象以上泥盆紀之 *Phillipsastraea* 屬爲最顯著。此屬乃從牆壁發育之一屬進化而來。不特此屬爲然、凡各譜系中之末期生物 *end members* 莫不皆然。羣體珊瑚生長過密、其外部各個體之外壁、常結合成圍牆 *peritheca*、以圍繞珊瑚全

珊瑚虫驟然縮小、而孟部上部如蓋者。（即珊瑚之孟部極小）凡珊瑚直徑縮小、所以表明珊瑚身體收縮、亦即爲其衰老之一證。所以致此者、或因受病而身體損傷、或因境遇不適合而減小其體格。

有時珊瑚虫收縮後、旋即張開、呈互疊圓錐形。此類珊瑚收縮雖緩、然每次收縮必繼以擴張、故孟部極無規則之可言（如第八圖）雖或不甚顯著、然視珊瑚外部之同心生長皺紋 *concentric growth wrinkles*、固自有其例矣。

單體珊瑚多爲灣形、（第六圖）尤以具細長圓錐形者爲著。孟部之所以灣曲、實由于造成外壁石灰圈之厚度不均、灰質堆積最厚處爲凸邊 *convex side*、凸邊每爲主隔壁 *cardinal septum* 所在處。間亦有在對隔壁 *counter septum* 或側隔壁 *alar septa* 兩處者。曲度方向之變更、恆在九十度以上、故孟部之平面常與珊瑚幼部之軸平行、如 *Pinnatophyllum norini* 是。

珊瑚生長方向之驟變、本非通例、然未變以前、其生長方向極有規則、後因珊瑚虫衰弱、故生長方向亦變、所生之新方向、常與其舊方向成垂直。（如第九圖）

珊瑚生長之情形

珊瑚初爲極細部分、曰原部 *initial portion*。生長於他種物體上、或自由生長不與他種物體相連接。然具細長之原管 *initial tube*、每以一端與他種物體相連接、其相連處爲組成外壁之物質、發育特甚、常成極無規則之底。蓋環境使然也。

同種珊瑚生長於流水中者、其底強、生長於靜水者、其底弱、因無他種物質加入故也。蓋珊瑚能造成堅固之底

然大半珊瑚直徑之增大時期、初期尤勝於末期也。

珊瑚盃部之爲平盤狀、即珊瑚生長於硬物體上之結果。例如近代之 *Manicina* 屬珊瑚、生長於硬海底上者、其形狀率扁平、生長於軟海底者、每爲圓錐狀、此乃環境 *environment* 適合使然、或爲天然選擇 *natural selection* 之結果。如珊瑚有成平底之能力者、始能寄居於硬物體上、具圓錐形者、即易埋沒軟泥中。

珊瑚對於海底之適合理論 *theory of adaptation*、或可用以解釋近代珊瑚、然古生代珊瑚每不適合、因平底狀之 *Microcyclus* 屬常與圓錐狀之 *Stereolasma* 屬同產一岩層中、且珊瑚之有盃部、乃其特別標記、非因適合而生。

盃部爲珊瑚之特別標記、且爲各種珊瑚分別之基礎。如擴張率 *rate of expansion* 速、則盃部多爲寬圓錐形。（見第二圖）擴張率小、則成長圓錐形。（見第四圖）珊瑚各屬各種之區別、似不完全根據擴張率、亦必具有他種變化 *variation*。大概珊瑚種類之變化、恒受環境之影響。如海水之成分、珊瑚虫之食物、皆足以影響珊瑚虫之生活、珊瑚虫生活既受影響、則珊瑚直徑之增加與石灰質之沈澱亦當不同。惟同產一地之珊瑚、其變化即爲生物之主要分別。考其發育情形、其譜系 *genetic series* 亦當不同也。

四射珊瑚之盃部、有時生長極有規則、有時至相當時期即止、則外壁之石灰圈、漸次由下上增、惟直徑不變、其結果成爲圓柱狀之盃部（底部仍爲圓錐狀）如第五圖。圓柱體直徑之大小、視珊瑚擴張之遲速爲比例。擴張率速、則其所成之圓椎體低、圓柱體之直徑、恆較圓錐體之直徑爲大。擴張率緩、直徑即變小、如第六圖。

四射珊瑚當經過圓柱生長時期 *cylindrical growth*、其直徑漸縮小、故盃部之口甚小。（如第七圖）亦有

外壁

自構造方面言之、四射珊瑚及無射珊瑚之緊要部分爲外壁、因珊瑚體悉爲外壁所包圍、而珊瑚體又包含其他各緊要部分故也。昔日每視珊瑚之隔壁 *septa* 爲重要部分、外壁不過爲內壁 *theca* 之後加物、此蓋由研究珊瑚者、多根據六射珊瑚之堅部 *hard parts*。（六射珊瑚之隔壁每與內壁相連）是以後生之內壁名爲眞壁、初發生之壁反爲外壁也。

既知四射珊瑚各個體之發育、則外壁爲珊瑚堅部之最要部分、已無疑義。珊瑚最初發生時、僅爲無隔壁之空盃、然大半常發見第一期之隔壁、其第二期隔壁漸次發生、隔壁發生愈早、則發育愈速。原生狀 *primitive type* 之珊瑚體常無隔壁、足證四射珊瑚爲無射珊瑚進化後之一科。

外壁初生、僅爲石灰質小塊、又稱珊瑚骨 *sclerites*、與幼珊瑚虫細胞相離、多數骨質結成底板 *basal plate*。珊瑚虫藉底板連接於他種物體上、此種物體或爲生物遺殼、或爲較古珊瑚之外壁、或爲海底之堅泥。珊瑚虫生長時、底板上之新石灰漸次增加、形亦增大。如底板由四周增加、則面積特別增大、外壁之生長線 *growth-lines* 爲石灰質次第增加之明證、且爲外壁之特別標記。設外壁上石灰圈 *calcareous rings* 增加率與珊瑚虫生長率相等、則成平盃狀。古生代之珊瑚之屬此者、如 *Palaecyclus*（第一圖）*Microcyclus*, *Baryphyllum*, *Combophyllum* 及 *Hadrophyllum* 等。然古生代珊瑚石灰質之增加率、大半較速於珊瑚虫底部直徑之生長率。是以石灰圈恆由下而上、（非由內向外）遞次增加、層層相疊、宛如圓錐狀之盃部、普通珊瑚常有之。平盃狀之珊瑚、其底部亦有爲圓錐狀者、後因四周擴張、致成平盃狀、此即表明珊瑚四周增長速度以末期爲最大。

中國古生代之珊瑚化石

葛利普原著
孫雲鑄譯述

第一部 四射珊瑚

四射珊瑚 *Tetraseptata* 科之各種珊瑚、赫克氏 *Heckel* 常稱之爲四珊瑚類 *Tetracorallia*。愛德瓦斯氏 *Mine-Edwards* 則謂之多放線類 *Zoantharia Rugosa*、法拉希氏又謂之翼珊瑚 *Pterocorallia*。余以爲此類珊瑚之特徵以具有四隔壁、故名之曰四射珊瑚。猶之六射珊瑚之隔壁爲數六、八射珊瑚之隔壁爲數八、無射珊瑚之隔壁常不顯露、或僅爲刺狀體也。

無射珊瑚 *Asciptata* 及四射珊瑚 *Tetraseptata* 兩科多屬古生代。始則由原始之無射珊瑚進化、繼即分爲兩類。六射珊瑚又由四射珊瑚進化而來、故六射珊瑚進化初期中、常顯有原始四射式階級 *primitive tetrasetate stage*。

構造概論

珊瑚 *corallum* 由珊瑚虫 *polyp* 分泌物質而成。或爲單體、或爲羣體、視珊瑚虫之數目而定。羣體珊瑚之個體、謂之珊瑚個體 *corallites*。由單獨珊瑚虫 *polypite* 分泌物質而成、常與附近之各個體相連接。珊瑚之爲單盃形者曰盃部 *caliculum*。外壁 *epitheca* 以內之面積爲珊瑚體 *thecarium*。珊瑚體上部之盃形凹穴爲萼 *calyx*。珊瑚體內之各種構造極複雜、分述之如次。

四射珊瑚之體形學

中國古生代之珊瑚化石

古生物誌乙種第二號

葛利普著

第一冊

中國古生代珊瑚化石

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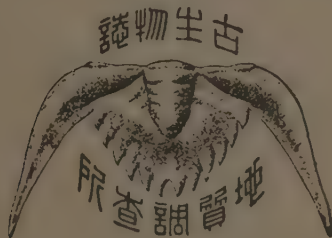
PALAEOZOIC CORALS OF CHINA PART I TETRASEPTATA

II SECOND CONTRIBUTION TO OUR KNOWLEDGE OF THE
STREPTELASMOID CORALS OF CHINA AND
ADJACENT TERRITORIES

III
AMADEUS W. GRABAU, S. D.

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PALAEONTOLOGY IN THE COLLEGE OF SCIENCE OF THE
NATIONAL UNIVERSITY, PEIPING.

WITH VI PLATES AND 22 TEXT FIGURES



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PALÆONTOLOGIA SINICA

Editors:

V. K. Ting and W. H. Wong

Palæozoic Corals of China

Part I. Tetraseptata

II. Second Contribution to our knowledge of the Streptelasmoid Corals
of China and Adjacent Territories.

AMADEUS W. GRABAU S. D.

Chief Palæontologist to the Survey and Professor of Palæontology
in the College of Science of the National University, Peking.

With VI Plates and 22 Text figures



Published by the Geological Survey of China.

Peking 1928.

莊子第二十二知北遊篇

萬物一也。是其美者爲神奇。其所惡者爲臭腐。臭腐復化爲神奇。神奇復化爲臭腐。故曰通天下一氣耳。

"The Evolution of beings follows an inherent,
unformulated law."

Chuang-Tzu, Chapter 2
Fourth Century B.C.

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PALÆOZOIC CORALS OF CHINA.

PART I—TETRASEPTATA

II. Second contribution to our knowledge of the Streptelasmoid Corals of China
and Adjacent Territories.

BY

Amadeus W. Grabau, S. D.

INTRODUCTION

The progress of Palæontological discovery in China brings to light new material which requires the issuing of supplementary studies to those already published in the fascicles of the Palæontologia Sinica. The present fascicle records the results of the further study of the Families *Petræidæ*, *Polycælidæ*, *Streptelasmaidæ* with the sub-families, *Tachylasmaïnæ*, *Plerophyllinæ*, *Sochkineophyllinæ*, and the families *Laccophyllidæ*, *Lophophyllidæ*, *Lindstræmidæ*, *Hapsiphyllidæ* and *Cyathaxonidæ*.

In addition to the discussion of new types obtained from China, it is desirable to note related species from adjacent territories and to consider the generic affinities and the relationships of the new species which have been described from other regions so far as they fall into the families under consideration. Special attention must be given in this connection to the important work of Dr. H. Gerth on the Permian corals of Timor, which appeared in the "Palæontologie von Timor" in 1921—that is the year before the appearance of the first fascicle of the present series but which has not become available until now. There has also recently (1925) been published an article on the Lower Permian corals of the Artinskian stage of the Urals by E. Sochkine of Moscow and this contains several species of our genus *Tachylasma*, as well as other forms which must be taken into consideration in this connection. The finding of *Polycælia* in the Permian rocks of Greater China furthermore requires a detailed discussion of the characteristics of this genus and the affinities of the types that have been referred to it.

Pocta in his monograph on the Palæozoic corals of Bohemia in Barrande's *Système Silurien du center de la Bohême* Vol. VIII part 2 divides the Zoantharia Rugosa or Tetraseptata into 3 groups.

1. Expleta. Dybowsky.
2. Semiplena. Pocta.
3. Inexpleta. Dybowsky.

Under the last of these the *INEXPLETA*, he places simple corals without tabulae or vesicular structure of any kind and includes in them the family of *Petraiidae* of which the genera *Petraia* Münster, *Orthophyllum* Pocta, and *Paterophyllum* Pocta, have Bohemian representatives. Under the group *SEMIPLANA* he includes a number of rugose corals in which the endothecal structures are not developed, occupying at most the lower part of the corallum. Especially the tabulae are not at all developed and the central part of the corallum is occupied by deposits of sclerenchyma, forming a sort of columella. Or else the tabulae are much reduced and are enclosed in a central tube which occupies the place of the columella. The vesicles are also strongly modified. They have the form of trabeculae which unite the pseudo-columella to the septa or wall of the corallum. The corals are simple and the calyx deep. He would place, under this group the genera *Permia* and *Timania* described by Stuckenberg from the Carboniferous (Permian) of the Urals and two families represented in the Bohemian deposits. These are the family *Lindstrœmidæ* Pocta, including the genera *Lindstrœmia* Nicholson and the two new genera *Alleynia* (*Nicholsonia*) Pocta, and *Barrandeophyllum* Pocta. The second family is that of the *Polycorallidæ* in which he places his new genus *Oligophyllum*, which however belongs elsewhere.

The remaining group, that of the *EXPLETA* includes all the other corals in which the endothecal tissue is well developed.

This is evidently an artificial classification and while groups of this type may be a convenience, it cannot be said to include related families.

It may also be questioned whether the family of the *Lindstrœmidæ* represents a group of related types. The complex stereocolumella of *Lindstrœmia*, formed of septal ends, with added stereoplasm rather suggests some of the more specialized columellas such as characterize some of the later Carboniferous forms.

I cannot see any reason for placing such specialized genera as *Alleynia* (*Nicholsonia*) and *Barrandeophyllum*, in which the septa are joined into a true phyllothea in close relation to *Lindstrœmia*, for certainly the origin of this inner wall is quite distinct from the complex stereocolumella of that genus. If the family *Lindstrœmidæ* is to be retained these two last mentioned genera must certainly be removed from it. Moreover it is doubtful if the species described by Pocta is really congeneric with the type species of *Lindstrœmia*. The 20 to 26 septa shown in Pocta's species are rather thickened towards the center. Bilateral arrangement seems to be indicated by the fact that the septa on either side show what appears to be a pinnate disposition. The major septa (primary and secondary) are joined at the inner ends where they are somewhat thickened by stereoplasm. Pocta's figure

shows no suggestion of the complex stereocolumella, but seems to have the center free from deposits. He says however "Les plus longues sont jointes ensemble au centre du polypier, par un puissant dépôt des sclerenchyme, et forment ainsi la pseudocolumelle" (page 184).

This pseudocolumella formed by the thickening of the ends of the septa is, however, quite distinct from that seen in typical *Lindstroemia*. The family is redefined on a later page.

DISCUSSION OF FAMILIES AND GENERA WITH DESCRIPTION OF NEW SPECIES.

Family **PETRAIIDÆ** de Koninck (emend. Grabau).

(See Fascicle I page 27).

In the descriptive part of the earlier monograph I have included under the Petraiidae only the two genera *Petraia* and *Polycerlia*. The latter is now removed to its own family and to the former we must add the two genera *Orthophyllum* Pocta and *Paterophyllum* Pocta. All of these are characterized by the simple development of the septa, the absence of dissepiments, tabulae or columella, and the general primitive character of the corallum. In the most primitive members of this family we should expect to find the septa merely in the form of ridges on the calyx wall, the basal part being without septa altogether. That is the condition seen in the actual young specimens of *Petraia* (*Streptelasma*) *profunda*, of the American Ordovician, as described by Gordon from young specimens in the collection of Columbia University. Some of the known species commonly referred to *Petraia* approach this condition very closely, but usually the septa extend at least part-way to the center in the bottom of the corallum.

Genus **PETRAIA** Münster

Plate I, Fig. 1.

The genus *Petraia* was founded by Münster on specimens of these corals obtained from the Upper Devonian of Germany. The species described by him, are *P. disciformis* Münster, *P. radiata* Münster, and *P. tenuicostata* Münster. The first of these will probably have to be regarded as the genotype. In addition to these, Frech has described *P. barrandii* from the same horizon. A number of species have been described from the Silurian of England, the Baltic provinces of Russia, and the United States and at least 6 species are known from the Ordovician of England. Pocta has described a number of species, distributed as follows. From

horizon e_2 *i. e.* Lower Silurian 6 species. From the lower part of the Middle Devonian g_1 , 2 species and from the higher g_2 , 1 species. Whenever well preserved, these show the pinnate arrangement of the septa in the costal grooves on the exterior, while in all cases the calyx is deep, with the sides marked by the septal ridges but with the septa extending at least part-way to the center in the lower part, in exceptional cases quite reaching it. In the Silurian forms at least, the septa retain the primitive quadripartite arrangement this being less marked in the Devonian species where the tendency towards radially appears. In several of these Bohemian species the interesting fact is brought out that in this generic group the degree of acceleration is not as yet a fixed matter, for while in some of the forms that are known elsewhere, the quadrants are equally developed and in others the counter quadrants show acceleration, there are at least some of the Bohemian forms in which the cardinal quadrants are the accelerated ones. This is especially brought out in the case of *Petraia indifferens* Pocta from horizon e_2 , as illustrated in the section on Pl. 108 fig. 11, reproduced here as Fig. 1, Plate I. This is a small species reaching a height which varies from 15 to 25 mm and a calicinal diameter ranging from 20 to 28 mm. The depth of the calyx is great, the portion in which the septa are developed occupying only $1/4$ of the height. The cardinal septum is well-developed, thick, and reaches about half-way to the center. The alar are also strong and longer, while the counter septum is slightly shorter than the cardinal. There are 5 secondary septa in the cardinal quadrants, all of them united to each other and to the alar septum on one side, but partly free on the other. The counter septum itself is free, but the secondary septa are united into groups or largely so, though there are only four secondary septa in the counter quadrants. This shows a distinct acceleration of the cardinal quadrants which have one septum more than the counter quadrants. In the section of the very early stage of this same individual shown in fig. 14 of Pocta's plate 108, the septa are shown to be only slightly less developed, all of them uniting in a somewhat excentric point nearer the counter side, where there is a slight re-enforcement or thickening by secondary stereoplasm. The cardinal septum is long while the secondaries of the cardinal quadrants number four on each side, all of them united and joined to the alar septa. In the counter quadrants there are 3 secondary septa also united, thus the proportion is the same, the cardinal quadrants being accelerated by one septum.

Another one of the Silurian species of Bohemia *Petraia discreta* Pocta (loc. cit. pl. 112, fig. 4) (Text-fig. 1a) shows a slightly different development. The corallum in this case is a slender cone, being about 20 mm in height but with a calicinal diameter of only 8 mm. The epitheca in the specimens described is lacking but

the margins of the septa show a pinnate disposition. Pocta says that only the alar septa are distinguishable, the cardinal septum not being recognizable, this being the more remarkable, since in the interior of the calyx only the cardinal and counter septa are strongly developed, while the alar are not distinguishable. The calyx is deep, the septa appearing as ridges on the inside reaching their full development only in the lowest part. In a section just below the calyx bottom, 2 free septa are indicated, reaching $\frac{2}{3}$ the way to the center, while the others are united into a solid group on either side. These free septa are the ones designated the cardinal and counter by Pocta, and if he is correct this would give the remarkable result of having an asymmetric development of the septa, for the group on one side comprises 11 septa while the number on the other is only 7. While such asymmetric development is not an impossible feature, it becomes rather remarkable when taken in connection with the fact that all the septa are united into a single group on either side, that is, according to Pocta's interpretation, the septa of the counter and cardinal quadrants on each side are both joined to the alar between them. It is furthermore remarkable that these alar septa should be indistinguishable when they are so well marked on the exterior, while the cardinal and counter septa are strongly developed when there is no external indication of their position. I suspect that the section is really to be interpreted in another way, namely that the alar septa are free and the conjoined septa on one side represent those of the cardinal quadrants joined with the cardinal, and those of the other, the counter and counter secondaries conjoined. If such an interpretation is permissible, it would seem from the disposition of the septa that the larger group represents the cardinal quadrants, each quadrant with 5 septa, while the counter quadrants have only three. This would again show that the cardinal quadrants of this species are accelerated, in this case even more so than in the preceding species. This is suggested by the lettering of the section in our reproduction in Text-fig. 1a.

Of course, this interpretation is only suggested, its validity must be tested by recourse to the original material; and if the alar septa are so well indicated on the exterior, it ought to be possible to trace them into the calyx or to prepare properly oriented sections. The reverse may of course be true *i. e.* that the smaller group represents the cardinal quadrants, the fewness of the septa in that case being responsible for the failure to recognize it on the exterior. In that case the present species would represent acceleration over that unquestionably shown in the preceding one. But so far as one may judge from the illustration of the section, the first interpretation, namely that the smaller group represents the counter quadrants, is the more likely.

When we come to the Devonian species of the Bohemian *Petraias*, we find a slightly different picture. *P. belatula* Pocta (loc. cit. pl. 68, figs. 17-21, pl. 112 figs. 8, 9) from the lower part of the Middle Devonian (g_1) is a rapidly enlarging conical form, the smaller reaching a height and calicinal diameter of 15 mm, while others with a height of 20 mm may have a diameter of 26 mm and still others reach a height of 26 to 28 mm with about the same diameters. The pinnate arrangement is well shown in the costal grooves on the exterior. The calyx is deep, the septa reaching their full development only in the basal $1/5$ of the corallum. Their arrangement here is almost a radial one, though there is a slight development of irregularity, many of them having a somewhat flexuous character. They reach at best only $2/3$ the distance to the center and are practically all free. It is, however, impossible to determine from the section the principal septa, and Pocta does not state the number of secondary septa in each quadrant, though this might have been very readily ascertained from the costal grooves on the exterior. Without further study of the original material, it is thus impossible to determine which of the quadrants are accelerated. A section of the same specimen at a lower point (Pocta pl. 112, fig. 9) shows the septa free or nearly so even at that stage. They reach nearly to the center and at best two adjoining ones merely touch at their inner ends. There are 17 rather unequal septa at this stage, whereas there are 20 higher up, though one or two of these, which are very short, might be tertiaries. If they are newly formed secondaries, then their position is on either side of the cardinal septum, but even that does not help us to locate the alars definitely. There are, however, two features which may make this possible. On one side we have a wider space and on the other a small new septum has appeared in the corresponding space, adhering to what, in that case, would be the alar. If that orientation is correct there would be 5 secondary septa in the cardinal quadrants and 3 in each counter quadrant, the acceleration thus being comparable to that seen in the Silurian species.

It may be well to repeat, that these are merely suggestions, but it is hoped that they will call attention to these significant features, and lead to an accurate determination of them in the originals or in new material.

CHINESE SPECIES

Petraia sp. I.

Pl. VI, Fig. 1 a b, 2 a b.

Among the material obtained from the Silurian Lungma Shale of the Yangtze Valley, are two moulds of a coral with a very deep calyx, the latter being alone represented in the mould, which originally was surrounded by the rock matrix, with a

space representing the thickness of the coral wall between. This had to be removed but it was first noted that the wall was of very slight thickness. A fragment of this matrix, showing the impression of the exterior, indicates that the costal grooves were well-marked, sharp and narrow, with rather flatly rounded, broad interspaces, the whole characterized by moderately prominent growth-lines. It is also observable that these septal grooves clearly indicate the pinnate arrangement of the septa.

This pinnate arrangement is remarkably well exhibited in the septa of the calyx, represented of course in the mould by grooves. The septa have the character and arrangement of the septal ridges in the young specimens of *Petraia* (*Streptelasma*) *profunda* as described by my former student Dr. C. Gordon from actual young specimens in the collection of Columbia University, that is, the coral is a simple epithecal tube, cone-shaped, and with the septa forming low ridges on the inside, these ridges being arranged in a typical quadripartite manner, with the primary septa prominently marked. In the present case, the mould might almost be taken as representing one of these young corals, except that it does not taper to a point, which in the young specimens in question is always marked by the absence of septa. In the present form, the base of the cone, as represented by the larger specimen, (cat. 1678. Pl. VI, Fig. 1 a b) is broadly rounded off, with a dorso-ventral diameter of about 1.8 mm, while the height is 4.7 mm, and the dorso-ventral diameter at the upper end is 5.3 mm, the transverse at the same time, being 4.2 mm. If we prolong the slopes on either side, the length of the lower part of the corallum would be approximately 2.16 mm making the total length, as represented by the interior, 6.86 mm. This of course implies that the slope of the calyx sides are at the same angle as the exterior of the corallum. That they are not very far from it was indicated by the relative uniformity of the interval between the external and internal moulds. Nevertheless it is apparent that the lower part, somewhat less than 1/3 of the corallum, was occupied by the septa which met in the center as indicated by the grooves on the mould of the gently concave calyx floor. That the septa continued as mere ridges on the inside of the calyx, is indicated by the fact that the grooves representing them in the mould do not increase in depth downwards, indeed, become of slightly less depth towards the calyx floor.

In outline, the calyx was oval, the proportion of width to length being as 1:1.13. Part of this may of course be the result of lateral compression of which there is some slight indication.

The sides slope almost regularly to the gently concave bottom. The cardinal and counter septa are situated on the ends of the longer axis. The cardinal septum

was flanked on either side by a regular groove or pseudo-fossula, somewhat broader than its thickness, while the pinnately arranged secondary septa were joined along the margin of this groove by a thin ridge. Three secondary septa abutted pinnately against the cardinal group on either side, these being numbers 6, 5, and 4. Numbers 3, 2 & 1 reached the floor of the calyx independently but still continued across it to the continuation of the cardinal septum, so that it may be said that virtually all 6 septa joined the cardinal septum pinnately. The alar septa were in all respects like the secondaries and parallel to them, but they met the point of the cardinal septum on the floor of the calyx. In the specimen here under description, the unipinnate arrangement of the counter-secondaries, against the alar, is shown only on the left side of the calyx, the septa on the right side appearing parallel, the alar therefore being unrecognizable on this side except for its numerical position. Taking this into consideration, there were 4 secondary septa in each counter quadrant, although from the appearance of the mould and the somewhat stronger groove opposite the cardinal groove, which might represent that of the counter septum, five secondaries are indicated on the left side, the last two abutting against the alar. This, however, would only leave at the most 3 on the right side. In any case it is apparent, that in this specimen at least, the cardinal quadrants are accelerated to the degree of at least one if not two secondary septa in excess of those of the counter quadrants. Tertiary septa are well marked by grooves representing low ridges which however, were lower and thinner than those of the secondary septa. They were present in practically all the interspaces but died away before they reached the bottom of the calyx. It is this fact primarily which makes them easily recognizable in the mould. There is marked indication of a faint serration of the edges of the tertiary septa, and this structure is shown somewhat less pronouncedly for the secondary septa as well.

The second specimen representing this species is the calicinal mould of a smaller specimen (cat. 1640 Pl. VI, Fig. 2 a b.). The length of this mould is 4 mm while the basal part, determined from the lateral slopes, would add about 1.6 mm, making a total original length of the interior, as thus interpreted of 5.6 mm. The apical diameters are 4.8 and 4.2 mm for dorso-ventral and transverse, respectively, while the calicinal floor had diameters of 1.8 mm and 1.2 mm respectively.

Although evidently of the same species, there are certain differences, most marked of which is the different degree of acceleration of the quadrants. The counter quadrants had 5 septa each, whereas in the cardinal quadrants at this stage only 3, with an indication of a 4th secondary were developed, all abutting against the cardinal septum. The alar met the cardinal on the floor of the calyx and had

at least 3 secondary septa abutting against them on either side *i. e.* the 5th to the 3rd, the 2nd and 1st reaching the calyx floor independently as did also the counter, which was independent from the others. Tertiary septa were present in all the more important interspaces, extending nearly if not quite to the floor of the calyx and dying out, before reaching it. The impression of the serration of the septal margins are less strongly marked.

HORIZON AND LOCALITY: In the Lungma Shale, 350 metres above the base of the Sintan Shale, Lower Silurian, Lojoping, Ichang District, Hupeh. Collected Hsieh & Chao. Cat. Geol. Surv. China, Nos. 1639, 1640.

Petraia sp. 2

Pl. VI, Fig 3 a b.

A second species of *Petraia* is represented by an internal mould of the calyx with a slight amount of the matrix surrounding it and separated by an interspace which shows the thickness of the calyx wall. The characters of the present mould are somewhat obscured apparently by pressure, but it seems possible to make out the general nature of the septal arrangement. The calyx was much steeper and tapers to a point with the sides regularly sloping. There appears to have been a curvature to the coral, so that one side of the calyx was much shorter than the other. The longer and flatter side would appear to be that of the counter septum, if we judge merely by the apparent arrangement of the septa on the narrow sides of the calyx and their relation to the alar. This may, however, be misleading, and indeed it is not absolutely clear, whereas down the middle of the broad and longer side, there is a single median groove representing a septum which most probably was the cardinal. It was flanked by at least 3 secondaries which had a pinnate arrangement with reference to it, whereas the septa on the opposite or shorter side were all parallel, suggesting those of the counter quadrants. But the relationship on the sides seems contradictory though it is not wholly clear, the discrepancy being possibly due to compression.

Taking the orientation as indicated, there appear to have been at least 6 secondary septa in each cardinal quadrant, and 6 or 7 in each counter quadrant. Tertiary septa were much fainter and extended only half-way down the calyx side. All the septa, primary and secondary as well as tertiary had strongly spinose margins represented in the mould by a regular succession of circular impressions in the bottoms of the grooves representing the septal impressions. Apparently the spines were very strong, especially on the primary and secondary septa.

The following are the dimensions of the only specimen obtained, which it must be remembered is the mould of the calyx.

Length 6.8 mm

Dorso-ventral diameter 4.3 mm

Transverse diameter 5.5 mm.

HORIZON AND LOCALITY: In the Lungma Shale, 350 metres above the base of the Sintan Shale. Lower Silurian, Lojoping, Ichang Province, Hupeh. Collected Hsieh & Chao. Cat. G. S. C. 1641.

Genus **ORTHOPHYLLUM** Pocta.

Text Fig. 1. b-c.

This genus was instituted by Pocta for a number of Silurian and Devonian species of the general habitus of *Petraia* but with the septa in the adult attaining radial development. As in all these forms the pinnate arrangement is shown by the septal grooves on the exterior, but it becomes practically impossible to determine the primary septa from the published sections since these were not oriented. The calyx is usually very deep with the septa forming faint lines on each side and reaching their full development as in *Petraia* in the lower part of the calyx. They are radially disposed having entirely passed beyond the primitive quadripartite arrangement, which even in the earlier sections is not recognizable. There seems to be little essential difference between the Silurian and Devonian species, so far as acceleration in the septal development is concerned, for what is apparently one of the simpler types *O. bifidum* Pocta (*loc. cit.* pl. 112 fig. 13, pl. 113 fig. 17, pl. 114 figs. 6-7) (Text-figs. 1 d, 2 a) with 28 radial septa of equal length reaching $\frac{2}{3}$ the distance to the center and apparently without tertiaries, occurs in the Lower Devonian of Konjepruss. Here also occurs another species *O. viduum* Pocta (*loc. cit.* pl. 112 fig. 14) with 27 septa of rather variable length, the majority of which do not reach more than half-way to the center, and many of them not more than $\frac{1}{3}$ the distance, all being more or less radially arranged. It is not possible, however, to determine whether some of them are tertiary septa; if so, they are very irregularly disposed. Tertiary septa however appear in at least one Silurian species *O. præcox* (*loc. cit.* pl. 112 figs. 5, 6, pl. 113, fig. 11-12) (Text-figs. 1 b c). Here the septa are radial, there being 17 of nearly equal length, reaching within a short distance of the center, nine of these having tertiary septa joining them, while the other 8 are without tertiary septa altogether. It does not seem likely that these nine septa, all of which are alike, represent the cardinal quadrants, for in that case

the cardinal septum itself would be furnished with a tertiary septum which is contrary to the normal characteristics of this septum. It is more likely that the middle one of these nine represents the counter septum though if so it has only a single tertiary instead of the normal two. If this interpretation is correct we are still left with the difficulty of disposing the 8 septa in the other quadrants, unless we consider that the cardinal septum is entirely aborted, its

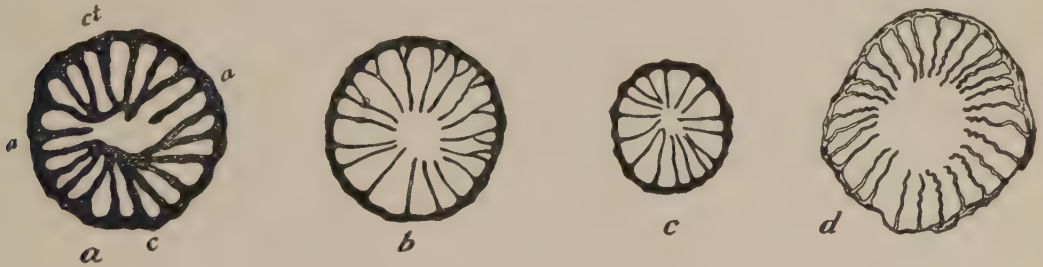


Fig. 1. Sections of *Petraia* and *Orthophyllum* much enlarged (After Pocta, with lettering added).

- a, *Petraia discreta* Pocta (E 2), Section of early stage with modified interpretation of septa; (Pocta pl. 112 fig. 4).
- b, *Orthophyllum praecox* Pocta (E 2), Section in upper part of corallum (Pocta pl. 112 fig. 5).
- c, The same individual as b, an earlier stage without tertiary septa. (Pocta pl. 112 fig. 6).
- d, *Orthophyllum bifidum* (Barrande) (F 2,) with septa (28) all alike and flexuose (Pocta pl. 112 fig. 13).

place being marked by the broadest interseptal space, which lies between the two groups of 4 simple septa. If that is the case, it is probable that the 4th of these simple septa on either side represents the alar, leaving 3 secondaries in each cardinal quadrant as compared with 4 in the counter, the latter being thus accelerated. Here again, however, it is necessary to have recourse to properly oriented sections, in which the principal septa are determined from the exterior disposition of the septal grooves. Moreover, it should be possible to determine the number of septa in each quadrant from inspection of these grooves alone, since the pinnate arrangement is shown on the exterior.

A much younger section of this same specimen shown in fig. 6 of Pocta's pl. 122 (Text-fig. 1 c), shows the septa wholly radial, but the tertiaries are entirely wanting. There are 16 septa in all, which, if the cardinal septum is developed, would leave 12 secondaries or 3 for each quadrant, thus indicating possible uniformity of development of the quadrants.

Another Silurian species *O. minusculum* (Pocta pl. 112, fig. 7), shows 19 septa radially disposed. One of the longer ones is flanked by a short one on either side. This may be the cardinal and if so the 4th from the cardinal on one side joins on to another strong septum which conceivably is the alar. The corresponding one on the opposite side is equally strong but not joined by either of the

septa. If this is a correct interpretation that would leave 8 septa for the counter and the secondaries of the counter quadrants, indicating asymmetrical development, though on the whole the quadrants would be essentially similar. Finally *O. conicum* (Pocock pl. 112, fig. 16) also from the Silurian (e 2) shows a very large number of septa many of which are oblique as if there were a tendency towards twisting. None of them reach more than $\frac{2}{3}$ the way to the center, the majority being of lesser length. There are at least 36 septa shown, though in one or two cases it appears as if there were more tertiaries still attached to the longer secondaries. Otherwise, however, the septa are free, and if there are tertiaries, they indicate a further development than that shown in *O. præcox*, i. e. towards radiality.

DISTRIBUTION OF THE SPECIES IN BOHEMIA:

SILURIAN (e 2:) *O. conicum* Pocock, *O. minusculum* Pocock, *O. præcox*, Pocock

LOWER DEVONIAN (f 2,) *O. viduum* Pocock, *O. bifidum* Pocock

LOWER MIDDLE DEV. (g 1,) *O. pingue* Pocock, *O. bifidum* Pocock.

CHINESE SPECIES

***Orthophyllum hupehense* Grabau (sp. nov.)**

Pl. II, Figs. 3-6, 8-10.

Corallum small, straight or slightly curved, rather rapidly enlarging and commonly somewhat compressed, so as to have an oval section. An average-sized specimen (Pl. II, Fig 4) has a length of 15 mm, a transverse diameter of 10.7 mm and a minimum diameter of 7.3 mm. This specimen is scarcely curved. A larger specimen (Pl. II, Fig. 3) has a length of 22 mm (22.5 mm along the curvature) a maximum calicinal diameter of 13.4 mm, and a minimum of 10.7 mm. The epitheca shows lines of growth crowded near the upper part, but the septal grooves in both of these specimens are very faintly developed, so that it is very difficult by their means to locate the principal septa. This seems to be true of most of the specimens obtained, though now and then a specimen shows a part of the septal grooves. In the only satisfactory one obtained, the cardinal septum appears to be located on the convex side, the compression thus being a dorso-ventral one, but even this specimen is not wholly satisfactory.

A transverse section of an early stage in which the compression was scarcely marked, shows a maximum diameter of 5.8 mm (Pl. II, Fig. 6 a). The septa are nearly all radial and very nearly reach the center. In one case, however, a group of four still shows a slight union at their inner ends. There are 24 long septa, comprising the 4 principal and 20 secondaries. One of the former, apparently

the counter, reaches to the center but the other primary septa cannot be differentiated and thus it is impossible to determine whether the quadrants are equal or whether there is any acceleration. It would seem however as if in this case the secondary septa were equally distributed, *i. e.* 5 in each quadrant, which would make the structure somewhat like that seen in *Polycoelia* except for the fact that the 4 primary septa are no stronger than the others. Tertiary septa are well developed and commonly still join the other septa. They reach a little more than one third the way to the center. No dissepiments or other endothecal structures are shown.

A second section through the calyx of the same individual (Pl. II, Fig. 6 b) shows diameters of 7 & 8 mm respectively for the minimum and maximum. Only a few septa are well developed the others are mere carinations or short points. Among the more prominently developed septa, there is a gap occupied by a septum only half as long as the adjoining ones. This appears to be the cardinal septum but it is not situated on either the minimum or maximum axis. Opposite it, is a still larger gap, without any septa at all. It is impossible to determine the exact number of septa, but this much can be stated, that the number has increased at least by two, if not by four from that found in the preceding section. The tertiary septa are equally recognizable over the greater part of the section, but they scarcely project beyond the thickened wall of the caliculus.

In the earliest section obtained (Pl. II. fig. 10) the diameter is 4 mm. There are 24 septa, the majority of which reach the center and they are all more or less thickened internally so that they form a solid stereoplasmic mass. The counter septum is somewhat longer than the others, the cardinal appears disrupted, while the alar join the counter in the center. As nearly as can be determined with the essentially radial character of the septa, there are 4 secondaries in the cardinal quadrants and 6 in each counter.

HORIZON AND LOCALITY: In the Silurian Lungma shales, 350 m above the base of the Sintan Shale; 80 li North of Lojoping Ichang, Hupeh. Coll. Y. T. Chao and C. Y. Hsieh, Geological Survey of China. Cat. 1559, 1560, 1561, 1562 & 1566.

***Orthophyllum lojopingense* Grabau (sp. nov.)**

Pl. II, Figs. 7 a, 7 b.

Corallum small, slightly curved at the base, but scarcely so in the later part, enlarging at about the rate of 1 in every 2 mm, in length, so that at the length of about 14 mm the diameter is 7.1 mm for the minimum. The surface is scarcely

wrinkled and the septal grooves are very faintly marked except in the very young. A section taken a little higher, has a diameter of 7.5 mm and is essentially circular. The disposition of the septa suggests *Polycælia* but is somewhat less pronounced. The 4 primary septa, however, seem to be quite marked, the counter extending to the center, the alar nearly so, but not quite joining it, while the cardinal is somewhat shorter and enclosed by the secondary septa, some of which meet in front of it. If the determination of the alar is correct, then there are 5 secondary septa in each counter quadrant, with 6 tertiaries reaching less than $1/3$ the way to the center and scarcely projecting beyond the thickened wall, but free. In the cardinal quadrants there are 6 long septa on one side and 7 on the other, while in each case there is an additional short septum next to the cardinal which may or may not represent a tertiary. The tertiary of the cardinal quadrants are not free as a rule, but join the secondaries. All the septa are thickened in their outer half, where they form by lateral conjunction a rather thick stereoplasmic wall. The secondary and primary septa, however, projecting beyond this, quickly taper to a slender flagellum-like extension as seen in section, fully one half of the septum being thin and delicate and sometimes somewhat flexuous. No intrathecal tissue other than the septa is shown.

If it were not for the greater acceleration of the cardinal quadrants as here interpreted, one would be tempted to place this form in the genus *Polycælia* as an early representative of that type. It differs, however, sufficiently from the species of that genus in the long slender septa and their thickened outer ends and the more numerous septa in the cardinal quadrants, while the pseudo-fossula on either side of the cardinal septum is marked. On the whole it seems best to fit in the genus *Orthophyllum* of which it might be regarded as a slightly specialized form.

HORIZON AND LOCALITY: In the Silurian Lungma shales of Lojoping, Ichang District, Hupeh. Collected by Y. T. Chao & C. Y. Hsieh, Geological Survey China Catalogue 1563.

Genus **PATEROPHYLLUM** Pocta.

Text-Fig. 2. b-f.

This genus was created for another group of corals in which the structure is still relatively simple, and which Pocta also referred to the *PETRAIDÆ*. The genotype is *P. explanans* Pocta from the Lower Devonian f 2 and the lower Middle Devonian g 1 of Bohemia. (Text-fig 2. b-c).

The genus, however, also occurs in the Silurian (*P. consimile*) and extends into the upper part of the Middle Devonian g 3 *P. perlatum* Pocta (*loc. cit.* pl. 114, figs. 10-12). (Text-fig. 2 d-f).

One of the external differences between this form and *Petraia*, Pocta states to be the rapid enlargement of the corallum which is usually a broad straight cone sometimes flaring. The calicinal diameter in some cases equals twice the height (*P. humile* Pocta pl. 113 fig. 19 from f2) or ranges from 2.4 to 2.7 times the height (*P. explanans*) (f 2 and g 1) (Text-fig. 2 b). In the earliest representative of the genus *P. consimile* Pocta from e 2 the corallum rapidly enlarges to a trumpet-shaped calyx rim. The septal grooves indicate the presence of 78 septa which implies that the tertiaries are well developed. The cardinal septum is faint and all the septa are still united in quadrants, a fact which indicates primitive conditions while the presence of the tertiaries points to specialization. In *P. humile* on the other hand from the Lower Devonian (f 2) the cardinal septum is long and thick, the secondaries uniting in the center in a stereoplastic mass. The total number of septa is 24 to 38. Tertiaries have not been distinguished. In *P. explanans* of the Lower Devonian (f 2) and lower Middle Devonian (g 1) the enlargement as already stated is very rapid and the septal grooves are well marked while the cardinal septum is short but well developed (Text-fig. 2 c). It is flanked on either side by a secondary septum the two joining in front of it forming a Y, the stem of which is continued as a united septum to the center where it joins the median stereoplastic mass. Although the alar septa are well shown on the sides of the corallum by the pinnate arrangement, they are not determined in the section which was not fully oriented. The counter septum lies directly opposite the cardinal and its interrupted continuation formed by the stem of the Y-shaped flanking septa. It has the appearance of two septa joining in a Y fashion and continued united to the center with a median septum bisecting the top of the Y. This is probably deceptive and the structure is to be regarded as a single continuous inner septum which extends inward and is joined by a tertiary septum on either side. The first pair of secondary septa in the counter quadrants or the counter laterals are also joined by two tertiary septa each, one on either side, thus having the appearance of a three-pronged fork. The other septa are joined by one tertiary septum each, this being true of the alar septa as well as the others in both cardinal and counter quadrants. There are, however, two septa in which this double or two-pronged character, produced by the junction of the tertiary with the secondary septa, is not apparent, though there is an indication that it exists but is hidden in the thickened wall of the corallum. In the case of the two

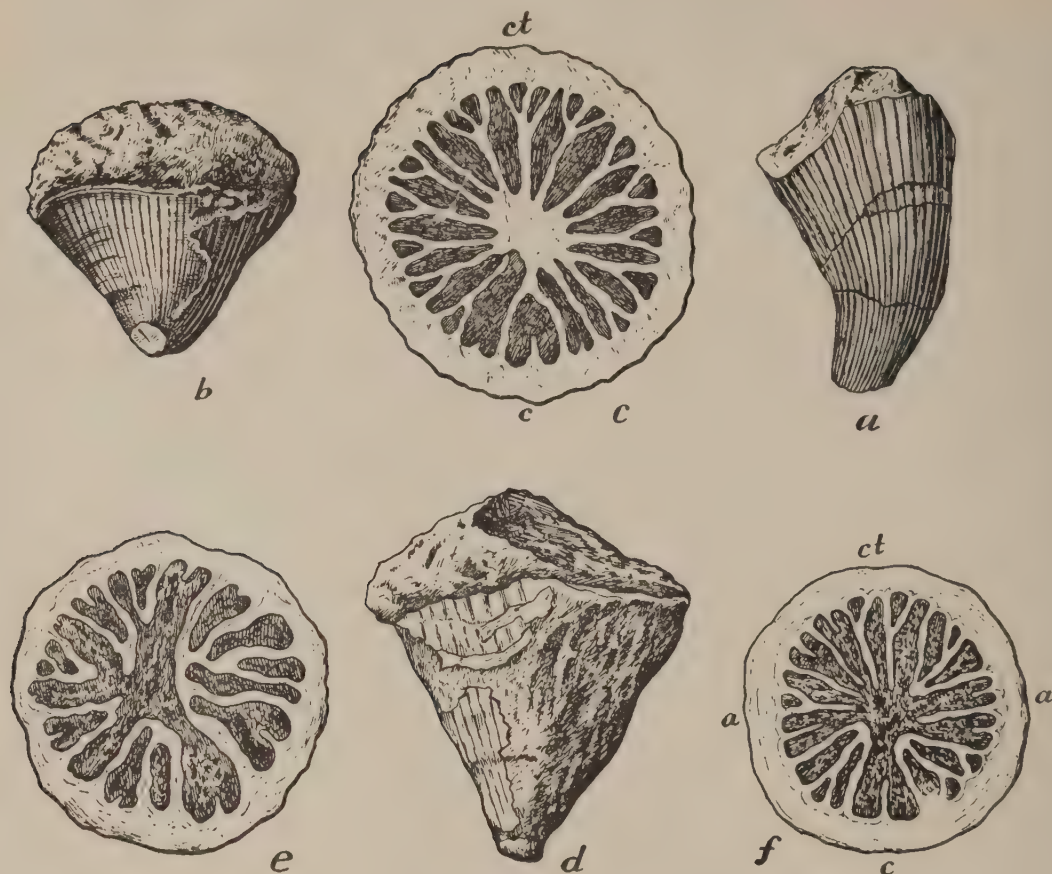


Fig. 2. *Orithophyllum* and *Paterophyllum* (after Pocta) all much enlarged.

- a. *Orithophyllum bifidum* (Barrande), a large individual showing the costal grooves. Konjepruss, Bohemia (f 2, Lower Dev.);
- b. *Paterophyllum explanans* Pocta; a corallum showing rapid enlargement, seen from alar side. Lochkov Bohemia (g 1);
- c. *P. explanans* Pocta, Cross-section of a corallum near the base much enlarged; same locality and horizon;
- d. *Paterophyllum perlatum* Pocta, specimen showing part of septal grooves; alar view. Chotu Bohemia (g 3);
- e. *P. perlatum* Pocta; Section of basal part much enlarged, the primary septa not identified;
- f. *P. perlatum* Pocta; section in higher part with provisional identification of septa.

septa which flank the cardinal, the tertiary is short and free, projecting at a small point from the thickened wall of the corallum, between this and the next adjoining septum. Including the counter laterals and the united, last-formed, cardinal secondary, there are altogether 14 secondary septa, although the alar septa are indistinguishable from the secondaries and so give the appearance of 8 long septa on either side between the cardinal and the counter septum. If we attempt to distribute these 14 secondary septa, we would probably have to assign 3 each to two of the quadrants and four each to the other two, but there

is no indication as to which of the quadrants are thus accelerated. From the fact that the counter and the two counter laterals have each two tertiary septa joining them, we may perhaps infer that the counter quadrants are accelerated, in which case this species would belong on the *Streptelasma* side of the family though it can hardly be considered ancestral to *Streptelasma*, being in the first place more specialized than primitive Streptelasmoids, and in the second place occurring in a much younger horizon than the typical Streptelasmoids which are chiefly Ordovician and Silurian. The present species represents rather an independent line of specialization. Although not the last member of the genus, it seems more specialized in some respects than *P. perlatum* of the late Middle Devonian. Aside from the central deposit of stereoplasm which unites nearly all the septa, and the great thickening of the wall by stereoplasm, there is no intrathecal tissue in the interseptal spaces, these apparently being open to the bottom as in *Petraia*.

P. perlatum Pocta (Text-fig. 2 d-f) from the Eifelian (g 3) is a somewhat less rapidly expanding form and grows to somewhat larger size (Pocta, pl. 114 figs. 10 to 12). In the section of the lower part of this specimen (Text-fig. 2 e) what appears to be the cardinal septum is very short, while opposite it is a group of 3 conjoined septa which apparently represents the counter and the two counter laterals, while a short tertiary septum projects as a free point between the counter and the counter lateral on one side. If this orientation is correct, then the remaining septa are divided into 2 groups. On one side there are 9 septa, all of them united into a single group; on the other side there are four groups of two septa each. Short, free tertiary septa occur in many of the interspaces. It is not possible to recognize the alar septa and indeed the entire interpretation seems to be at fault.

A section somewhat higher in the same specimen (Text-fig. 2f) shows a more radial arrangement of the septa. Again it seems necessary to interpret a short simple septum about half the length of the others as the cardinal septum. This septum is bordered by a rather broader space on either side, after which there is a group of 3 united septa which apparently form the three secondaries of the cardinal quadrants, several of them being furnished with tertiary septa which join them.

If the septum opposite the assumed cardinal is the counter, it has only one tertiary joining it. On one side of it, a group of 3 long septa are joined by their inner ends, the median one of these having an adhering septum. On the other side there are three free septa with tertiaries in all interspaces. These are free except in the case of the first counter lateral which has its tertiary joining.

Thus interpreted there are three secondary septa in each quadrant, while between the counter and cardinal group on each side is the long free alar septum, flanked by tertiaries on each side.

ABERRANT DERIVATIVES OF THE PETRAIIDAE

Genus **DITOECHOLASMA** Simpson

(Text-Fig. 3)

1900. Simpson. New Genera of Palæozoic Rugose Corals, p. 201 figs 5, 6.

This genus was erected by George B. Simpson for a peculiar little coral from the Helderbergian of Perry County Tennessee, which was originally described as *Petraia fanningana* by Safford. It is a simple, slender attenuate corallum gradually increasing in size, with the septal grooves marked in the epitheca which is somewhat thickened within. The septa show a peculiar arrangement, in that they are all united into

groups which give a peculiar aspect to the cross-section. Unfortunately there has been no correlation, so far, between the septa and the external grooves, so that it is not entirely possible to determine the position of the principal septa, though from their general character we may perhaps be able to determine the cardinal, and the counter septum, which join in the center and bisect the corallum. What appears to be the counter septum is joined on either side by a rather long tertiary septum, these forming, with the counter, a triple group of the usual type. Joined to the inner end of the counter septum is a group of two secondary septa on either side, the two septa uniting just before



Fig. 3. *Ditoecholasma fanninganum* (Safford)
Transverse section showing the peculiar arrangement of the septa (enlarged). Longitudinal section showing the sclerocolumella and tabuloid dissepiments (enlarged). Helderbergian of Perry Co Tenn. (After Simpson).

they join the counter septum. Each of these secondary septa is also provided with a long tertiary one, which joins it on the counter side. Thus the triple counter group is flanked on either side by a quadruple group of secondary and tertiary septa. What is taken to be the cardinal septum also joins this group, but remains essentially simple. The septa adjoining it are differently grouped on opposite sides. There are four long ones in each case, each with a tertiary adjoining, but most of these are again joined into pairs. Two of these would probably have to be considered the alar septa, each of which has a tertiary adjoining; the other three, each with its tertiary, would then represent the secondary septa of the cardinal quadrants.

If this interpretation is correct, the cardinal quadrants in this form are accelerated by one septum. No other interpretation seems possible from the study of the section given by Simpson.

The junction point of the longer septa is marked by the deposition of sclerites of stereoplasm, rather loosely associated into a sclerocolumella, not unlike that of *Enterolasma*, though more slender. This is joined by delicate tabuloid dissepiments, which are either horizontal, or bend down slightly toward the pseudo-columella. But apparently these do not have any marked influence on the calicinal view, since that appears to be wholly free from dissepiments and stereoplasmic deposits, probably because of the fact, that the delicate tabuloid dissepiments are nearly horizontal.

This coral is unique and evidently represents a lateral derivative from Ordovician *Petraiidæ*, a relationship to that family being indicated by the simplicity of its septal arrangement. So far as we know it has no near relatives.

Family **POLYCOELIDÆ** Roemer

The division of the Polycoelidæ, to which family rank was assigned by Roemer, is here re-instated with the two genera *Polycoelia* King and *Gerthia* Grabau (nov.) as the only representatives at present well understood, though other genera also appear referable to it. The family may be characterized as follows:

Simple corals, of relatively primitive character, in which the four primary septa are well marked, sometimes but not always thickened, and nearly reaching the center, but not uniting. Secondary septa equal in number in all the quadrants, or the counter quadrants accelerated. All septa more or less radial. In the most primitive species, the dissepiments or other endothecal tissue may be wholly or largely wanting, but in the more specialized forms, the dissepiments may unite into tabule in the centre. No columella. Tertiary septa may occur.

The family as now constituted is wholly Permian.

Genus **POLYCOELIA** King.

Text-Fig. 4.

So far as we are at present able to judge, considering our lack of knowledge of the ontogeny of the Petraiidæ, the genus *Polycoelia* represents only a slight modification of the primitive form of corallum through which the members of the Proteroseptata pass. The fact that all the species of the genus so far known, belong to the Permian, forbids the assumption that the genus itself may be regarded as primitive. It is to be considered rather, as a retarded representative of primitive proteroseptate types.

Up to the present, it has not been possible to obtain any insight into the early stages of this generic type, for no serial studies of the typical species, *P. profunda* Germar (Text-fig. 4) from the Zechstein, appear to be available, or if they have been made, I have not seen them, and the only other typical species now known to me, that from Mongolia, has not so far been obtained in young enough stages to permit such studies to be made. However, it would appear from the character of the septal grooves visible on the exterior of the corallum, that this does not differ from the normal mode of development of the simple Palæozoic Tetraseptata.

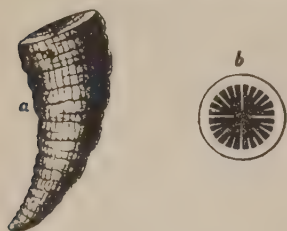


Fig. 4. *Polycoelia profunda* (Germar); a, lateral view and b, section through middle of the corallum. Natural size. Lower Zechstein, Ilmenau Germany (After Roemer)

The most striking feature of the adult *Polycoelia* is the marked quadripartite arrangement of the septa. (Text-fig. 4) The four primary septa are longer and stronger than the others, and typically divide the caliculus into four equal parts. This is still marked in the adult stage, where the four primary septa nearly, but not quite, reach the center. The number of secondary septa in each quadrant is five, which further shows the perfectly symmetrical development of this coral. In the typical species, the median one of these five appears to be longer than the others as if this median, in each case, represented the first of the secondaries. If that were the case, and this can only be determined by a careful study of the serial development of the septa in an individual, the two shorter septa next to the counter septum on either side, must be regarded as tertiary and quaternary respectively, while the same designation would have to be applied to the two shorter septa next to the alar septum on each side in the cardinal quadrants. If, however, the shorter septa appear in pairs on either side of the median septum of the quadrant, the septal development would be markedly different from that of the normal Tetraseptata, and this group would have to be referred to a totally distinct branch of the Tetraseptata.

There seems, however, to be no special reason for assuming this order of development, and the greater length of the median of the five septa in each quadrant, must be regarded as a subsequently developed modification, the greater development of the third septum being a case of local acceleration not unknown in other late Palæozoic corals of this group. Certainly so far as it is possible to determine the order of septal development in Mongolian species, this conforms wholly to the Tetraseptate plan.

Tertiary septa are either not developed at all, or else are indicated by the septal grooves on the exterior, though in rare cases they may project beyond the thickened

epithecal wall. In the highly modified species from Timor, referred by Rothpletz and Gerth to this genus, but here made the type of the new genus *Gerthia*, tertiary septa are recognizable.

So far as it has been possible to ascertain from the material now available, intrathecal structures, other than the septa, are rare or wanting in typical species. The statement has been made, both by King & Geinitz, that a few irregular tabulæ are present in the European species, though these, according to Geinitz's illustration, are incomplete. Ferdinand Roemer on the other hand* states that two individuals, which he sectioned lengthwise, showed no indication of such tabulæ. Dissepiments, however, occur in the larger of the Mongolian species, but appear to be wholly wanting in the smaller one.

Genus **PHRYGANOPHYLLUM** De Koninck

De Koninck has described the genus *Phryganophyllum* with *P. duncani* De Kon. as the genotype and only representative, occurring in the Carboniferous limestone of Tournai**. This is likewise a conical, more or less curved form, with the primary septa most prominent, and arranged in a cruciform manner. The main difference between this genus and *Polycoelia* is stated to be the abundance of distinct well-developed tabulæ, and the calyx is shown in De Koninck's figure to be floored by a flat tabula on which the septa extend only a short way towards the center. Moreover, the number of secondary septa is much greater, and two of the quadrants (the counter?) seem to be accelerated, containing 9 or 10 secondaries, while the opposite quadrants (cardinal?) contain only 8 each. Tertiary septa are also well developed. De Koninck's species, however, is a Lower Carboniferous or Dinantian one, and so occurs long before the period in which typical *Polycoelia* appears. It cannot then be considered a modification of the latter, though in respect to the tabulæ, and the greater number of septa, it is a more specialized form than the Permian type. Thus it has to be considered an independently developed type, perhaps from the same general ancestral stock, the septal similarity in the two forms being merely a case of parallelism. Nor is it likely that *Phryganophyllum* is ancestral to *Polycoelia*, a supposition which might receive some support if the statement that *Polycoelia* has tabulæ in the young stage is correct. In that case the loss of tabulæ in the later stages merely indicates a declining, degenerate, characteristic. Nevertheless, the much greater specialization of *Phryganophyllum* suggests its entire distinctness.

* *Lethæa Geognostica* Part I, Vol. I, page 398, footnote.

** *Recherches sur les Anim. Foss. du Terrane Conbonifère Belgique*, Pages 62 & 63, Plate IV, Fig. II.

MONGOLIAN SPECIES OF POLYCOELIA.

Polycœlia cylindrica Grabau.

Plate I Figs 2 a-b; Plate VI, Figs. 14 a-b.

1928. *Polycœlia cylindrica* Grabau: Permian of Mongolia Mss. Pl. I, figs. 4-6. (In press)

This form, as the name suggests, is of an elongate cylindrical character, though it may retain a certain amount of curvature and a continued tapering, even in the apparently cylindrical form. Thus in one of the typical specimens (Pl. VI, Figs. 14a) the rate of change, over a length of 20 mm, is from 5.0 to 6.3 mm, while another fragment of a larger individual, ranges from 6.4 to 7.3 mm in the same interval.

The epitheca shows both wrinkles and growth-lines, and exhibits the septal grooves clearly. The calyx (Pl. I, Fig. 2b) shows 4 primary septa which are slightly thicker in their outer than in their inner region. The wall has been thickened by addition of stereoplasm, so that it, and the four primary septa, are of very nearly the same thickness. The presence of the secondary septa in the thickened wall is recognizable, while the tertiary septa are only indicated by the septal grooves. There is a slight asymmetry in the development of the four quadrants, two of them being somewhat smaller than the others, but it is not possible, with the material available, to determine whether the smaller quadrants belong to the cardinal or the counter septum.

The section (Pl. VI, Fig. 14b) shows the 4 primary septa symmetrical and extending two-thirds the distance to the centre. The secondary septa are of nearly uniform length, which is less than half the radius. There are normally 5 in each quadrant but in one only four appear. Again, there is a suggestion of an additional septum on either side of one of the primary (cardinal?) septa. Tertiary septa not shown. Dissepiments wanting.

HORIZON AND LOCALITY: The only specimens of this species so far obtained, were collected by Professor F. K. Morris from the Permian Limestone of Jisuhonguer Mongolia. The exact horizon of these beds is not known.

Polycœlia longiseptata Grabau (sp. nov.)

Plate I Figs 3a-b; Pl. VI, Fig. 15.

Diameter about twice that of the preceding species. The rate of tapering ranges from 1 in 11, to 1 in 16 or 17 mm, except at the lower end, where the tapering is more pronounced. The most nearly cylindrical fragment obtained (Pl. I, Fig. 3a), has a length of 38 mm., while the diameter enlarges from 9.4 mm at the lower end, to 10.5 mm at the upper. A somewhat more tapering specimen, 33 mm long, increases from 7.5 mm at the lower end, to 10.4 mm at the upper end. Generally the corallum shows a gentle curvature, and there are slight irregularities due to constriction and irregular growth-lines. Very fine growth-lines are also visible.

The exterior of the corallum is well marked by the costal grooves, there being 42 of these in an average specimen. Of the septa represented by these, 4 are primary, and since each quadrant has 5 secondary septa, the number of primary and secondary amounts to 24, which leaves 18 tertiary distributed through the 4 quadrants, these being distributed, so far as ascertainable, to the number of five in each of two of the quadrants, and 4 in each of the other two, thus indicating a slight acceleration of two of the quadrants. But whether the accelerated quadrants are the cardinal or the counter quadrants, cannot be determined from the material now available.

The cross-sections show the 4 primary and 20 secondary septa of similar length, and almost reaching the center in the earlier part of the corallum (Pl. VI, Fig. 15), but falling short of it in the upper part (Pl. I, Fig. 3b). A few dissepiments occur in the earlier section, these becoming more numerous in the upper part. (Pl. I, Fig. 3b). The tertiary septa are short, and indeed in some sections hardly recognizable. In a few cases, there has been noted an indication of a development of a quaternary cycle of septa, this being shown by an occasional fine costal or septal groove between those representing the secondary and tertiary, but this is an unusual feature.

HORIZON AND LOCALITY: This species has been obtained from two of the beds of the Jisuhonguer Limestone, namely the *Enteleles* Bed where it is most common, and the *Marginifera* Bed, from which a single specimen has been obtained. So far as has been ascertained, it is not associated with the other species, but further collections may revise this supposition.

There can be little doubt that this coral is referable to *Polycoelia*, despite the presence of the dissepiments. These appear to be a feature, primarily, of the later cylindrical part of the corallum. The fact that in *P. cylindrica* one of the quadrants has only four septa, and that in *P. longiseptata* one of the pairs of quadrants has occasionally only 4 tertiary septa, while only 5 occur in the other, instead of 6 in each, as should be the case if all the inter-septal spaces developed tertiaries, indicates that the septal development follows the general plan of that in the *Streptelasmaidæ* and other simple Tetraseptata.

OTHER SPECIES THAT HAVE BEEN REFERRED TO *POLYCOELIA*

Rothpletz in 1892 (Palæontographica XXXIX page 69, pl. 12, figs. 23, 31 & 32) described a coral from Timor under the name of *Polycoelia angusta*, which appears to have some relation to both the European and Mongolian species, though certain

features of the septal development indicate a rather marked specialization, which would seem to make it desirable to remove this species to a distinct genus. Gerth (1921, page 94, pl. 2, fig. 20-21; text figs. 9 & 10, reproduced here as Text-figures 5a; 5b) accepts the reference of this species to *Polycoelia*, but gives two transverse sections of specimens from Basleo, which indicate a striking difference in the septal character, though the calicinal view of this specimen, which he figures on his pl. 2, fig. 20, might lead one to accept the generic reference of this form, and regard it as a highly specialized species. Gerth describes this species as consisting of thin, long drawn-out corals, which, with a length of 3 or 3 $\frac{1}{2}$ cm, obtain a calicinal diameter of 6-10 mm, which is a size not differing much from our larger Mongolian species (*P. longiseptata*). He finds the epitheca transversely wrinkled, but the septal grooves are not well visible. The calyx is deep, its depth about equalling its diameter, with the septa forming only faintly indicated ridges on the abrupt calicinal wall. On the bottom of the calyx, the 4 primary septa first extend prominently to the center, the cardinal and counter septa being the strongest, and meeting in the center, while the alar septa are placed at right angles to these.

The secondary septa (metasepta of Gerth) are less developed than the primary (protosepta), their number, length and order of appearance being stated to be irregular as in *Plerophyllum*. Between these primary and secondary ones, tertiary septa (ectosepta of Gerth) are introduced cyclically, and these at an early stage may reach considerable length, rivalling that of the secondary septa. A large specimen, with 10 mm calicinal diameter, has 22 long septa, which would imply 4 primary and 18 secondary, probably 5 in each of the counter, and 4 in each of the cardinal quadrants, and 22 tertiary septa.

This at once indicates an irregularity of development of the quadrants, and such irregularity is prominently shown in Gerth's cross-section, where the counter quadrants appear to have 5 secondary septa and 4 tertiary septa each, unless the septum next to the alar is to be considered a tertiary rather than a secondary one, in which case there are only 4 secondary and 5 tertiary.

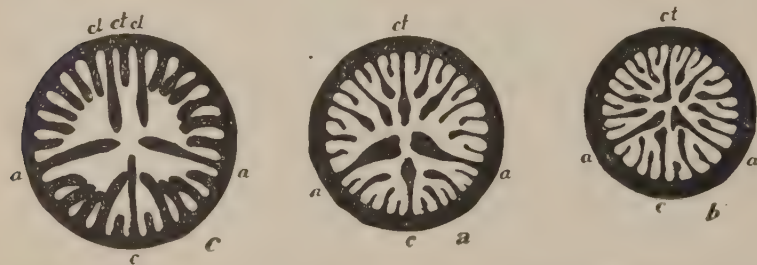


Fig. 5a. *Gerthia angusta* (Rothpletz) Section of corallum (diagrammatic) $\times 4\frac{1}{2}$; b. *Ibid*, Section of another corallum $\times 6$; c. *Plerophyllum radiforme* Gerth, diagrammatic section near the lower end of a small individual. Permian of Timor (Redrawn after Gerth with modified lettering); aa, alar septa; c, cardinal septum; cl, counter laterals or first pair of secondaries in counter quadrants; ct, counter septum.

Still it seems more probable that the last of these septa is a secondary rather than

a tertiary one. The first pair of secondary septa in these quadrants is shorter than the second pair, this being a case of retardation. From the second there is a regular decrease in length towards the alar. In the section, the primary septa show a pronounced club-shaped thickening of their inner ends. The secondary septa are also thickened, but not to the same extent as the counter septum, which in turn is less thickened than the alar or even the cardinal.

Tabulae or dissepiments are entirely wanting in this form which in this respect corresponds to typical *Polycoelia*. The marked acceleration of the counter quadrants, however, and the thickening of the septa, forbids the reference of this species to *Polycoelia*, although the calicinal view as figured by Gerth, (pl. II fig. 20) does not show the marked acceleration that is indicated in the text figures, which are here reproduced. (Figs. 5a-b).

Nor can this accelerated condition be regarded as the normal consequence of the cylindrical growth, for *P. cylindrica* from the Mongolian rock, still retains the primitive opposite position of the primary septa and the original number of five secondary septa in each quadrant. Moreover, neither in the Mongolian species nor that of the Zechstein, is the pronounced thickening of the septa seen, which marks a further modification in another direction. I therefore propose to establish for the Timor and allied species, if found, the new generic name of *Gerthia*, in recognition of the important work on coral morphology performed by the author of the monograph on the Timor Permian corals. The following then would be the diagnosis of this genus.

Genus **GERTHIA** Grabau (gen. nov.)

Simple, usually slender corals of more or less circular section, conical in the young but cylindrical in the adult forms. Primary septa prominent, thickened inward to a more or less club-shaped form in section. The counter quadrants distinctly accelerated, with a larger number of secondary septa than is found in the cardinal quadrants. First pair of secondaries in counter, and sometimes also in cardinal quadrants, retarded in development, so as to appear shorter than the second pair. Some of the secondary septa may also be thickened inward, but to a less degree than the primary. Tertiary septa more or less strongly developed. Tabulae and dissepiments normally absent (a few might be developed in highly specialized forms, but are at present not known); neither columella or pseudo-columella of any kind present, and septa not joining in the center.

GENOTYPE: *Polycoelia angusta* Rothpletz from the Permian of Timor.

This genus belongs of course in the same family with *Polycoelia*, either representing a derivative of a primitive form of this genus, or, what is more likely, a parallel development from a common ancestor. This is suggested by the fact, that in *Polycoelia*, the number of secondary septa in both cardinal and counter quadrants is five, a number apparently not reached in the typical species of *Gerthia*, unless the supposed tertiary septa are to be regarded as retarded secondaries. It is far more likely, however, that we have here a case of comparative retardation of the whole cardinal quadrants, which therefore remain in a more primitive state than in typical *Polycoelia*, in so far as the secondary septa are concerned, though the thickening of these septa, and the development of tertiary septa, indicates specialization.

SPECIES MORE DOUBTFULLY REFERABLE TO THIS GENUS

Gerthia? incisa (Ludwig)

Text-Figures 6 a-d

1869. *Astrocyathus incisus* Ludwig R. Korallenstöcke aus Paläolithischen Formationen. Palaeontographica, Vol. XVII, page 133, Pl. XXX, Fig. 4, 4a-4d.

The following is a translation of Ludwig's original description: "Corallum simple, pointedly conical with circular base, repeatedly constricted by very distant growth lines; calyx deep with 24 broad septa which reach to the round calyx floor, without carinae. In the interior of the corallum are many tabulae [dissepiments] between the septa. Width of calyx 0.7 cm. Depth of the same 0.8 cm. Exotheca [epitheca] strong.

"*Astrocyathus geinitzi* [*Polycoelia profunda*] from the Zechstein of Eisleben is a simple very deep cup without tabulae in the corallum, with a strong swelling at the base. It is thus different from this species, whose corallum is built up of cups inserted in one another in a funnel-form manner. *Ptychocalamocyathus gracilis* Ludwig, is a compound corallum and has only 6 septa. (Palaeontographica, Vol. XIV, page 216, pl. 63, fig. 5 a). This species too, our form does not resemble.

"In the lower Zechstein of Posneck in Thuringia, not rare".

In the analysis of the septal arrangement given by Ludwig for this species (pl. 30 fig. 4c) he figures 6 primary septa, which divide the calyx fairly regularly into sextants, and if his calicinal view, fig. 4d, is correctly represented, this hexameral arrangement is certainly indicated. This would hardly admit of placing this form near *Polycoelia* in which the 4 primary septa are so pronounced, but it would have to be regarded rather as a modification of a Streptelasmoid type in which two of the secondary septa have reached the length of the 4 primary. On the other hand it is perfectly

possible to associate this corallum with the species of *Gerthia* above described and there can certainly be no question that the general distribution, and relative length of the septa, closely corresponds to that given for the Timor species. Ludwig classifies his septa according to their length, in consequence of which, his second series of septa are seen to divide the 6 spaces medially, the resulting 12 spaces are again divided by a shorter septum each, which he respectively numbers 3 and 4, selecting this number with reference to the comparative length of the septa. If now we follow the method of analysis which we have taken in the case of *Gerthia angusta*, we would take 4 of the 6 long septa and regard them as the four primaries. The exact orientation of these would of course have to depend on the disposition of the septal grooves, which, to judge from Ludwig's fig. 4, are as well represented in this as in other conical *Tetrseptata*. So far as the arrangement in the diagram of the calyx is concerned, however, it does not matter which we select as the cardinal and counter. Having fixed on the cardinal however, we would name the next pair of long septa the alar, thus making the cardinal quadrants smaller than the counter. Now of the 7 septa in the counter quadrants, which we may number consecutively from 1 to 7 (Text-fig. 6c) beginning at the counter, number 2 may be regarded as the first pair of secondary

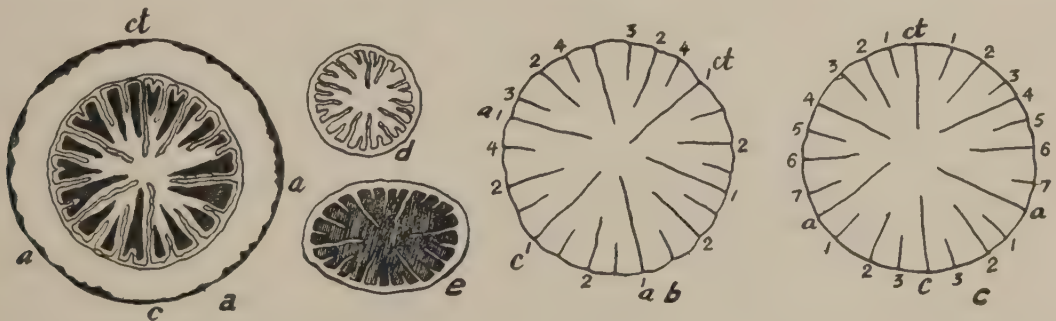


Fig. 6. a-d *Gerthia ? incisa* (Ludwig) (*Astrocyathus incisus* Ludwig); a Section of a specimen with septa enlarged by stereoplasm; with re-interpretation of the septal order (about $\times 7$); b. Diagrammatic analysis of septa on hexameral basis according to Ludwig. c. The same diagram re-interpreted on the tetrameral basis. d. Section of another individual also with 24 septa, of 4 orders of length $\times 3\frac{1}{2}$. Lower Zechstein, Posneck Thuringia. e. *Gerthia ? compressa* (Ludwig) (*Astrocyathus compressus* Ludwig); Section of calyx $\times 3\frac{1}{2}$, showing apparent hexameral septal arrangement. The cardinal septum is probably in the middle of one of the flat sides. Lower Zechstein, Posneck Thuringia (After Ludwig)

septa in the counter quadrant, no. 4 as the second pair, which has become, by acceleration, longer than the retarded first pair; the third pair is represented by no. 6 and the fourth by no. 7, though this may actually be one of the tertiary septa. What are undoubtedly, tertiary septa are the pairs numbered 1, 3 & 5 and possibly that numbered 7 as well. In the cardinal quadrants we have numbered the septa from 1 to 3 beginning at the assumed alar, and numbering towards the assumed cardinal, (see Text-fig. 6 c.)

These three septa may all represent secondaries, in which case the first pair of secondaries is retarded, as is the first pair of secondaries in the counter quadrants. On the other hand, the septa numbered 2, may represent the first pair of secondary septa in the cardinal quadrants, those numbered 3 representing the 2nd pair, while those numbered 1 represent the first pair of tertiary septa. Either of these interpretations would be in strict accord with the law of septal development in the Tetraseptata; the determination which of them is correct will have to depend on a re-study of specimens of this species.

In any case the arrangement of the septa of this form is closer to that seen in *Gerthia* than to that in *Polycoelia*, but there is no such marked thickening of the septa as in the former species. Moreover, according to the statement of Ludwig and the rather vague indication in his longitudinal section, tabulæ (or dissepiments) are well developed in *A. incisus*.

Ludwig has described a second species which appears to be congeneric with the first. His diagnosis may be given in translation as follows:

***Gerthia* (?) *compressa* (Ludwig)**

Text-Fig. 6 e

1869. *Astrocyathus compressus* Ludwig. Palæontographica Vol. XVII, page 134, Pl. XXX, figs. 5 a to 5 f.

"Corallum simple, pointedly conical, with oval base, externally smooth, with finely ringed exotheca [epitheca]. Calyx deep, 24 unequally broad septa in 4 series, without carinæ. The septa of the first order reach nearly to the middle of the calyx and meet nearly upon its floor. The corallum has many tabulæ. Maximum diameter of calyx 0.6 cm. Minimum diameter of the same 0.4 cm. Depth of calyx 0.8 cm.

"From the Lower Zechstein of Posneck in Thuringia. Not rare."

This species differs from the preceding one primarily in its lateral compression, the septal development being essentially the same, that is the second pair of secondaries exceeds the first pair in length. The section of one of the individuals given by Ludwig suggests that the cardinal septum is situated on one of the flatter sides instead of the end, this being indicated by the peculiar relationship of the septa and the stereoplasmic thickening. Since no definite discussion, however, is given of this section, its precise significance cannot be determined.

It is difficult to determine the precise generic status of these two Zechstein corals. That their affinities are with *Gerthia* we have already noted, this being

indicated by the manner of development of the septa which is of the same type in the two groups. Indeed, Ludwig's species might be regarded as ancestral to typical *Gerthia*, in which the chief modification has been the thickening of the septa; but the development of the tabulae in the Posneck species, indicates that this form is already highly specialized. The suggestion presents itself, that these species be separated under the generic name *Astrocyathus* given to them by Ludwig, but this term was applied by that author to a great variety of types which have no relationship to one another, and many of which belong to well recognized genera.

Indeed, in the 14 or more species described by Ludwig, we have an agglomeration of types which have hardly any other feature in common than that they are simple corals, and that the number of their septa can generally be divided by six, and perhaps also that there is a suggestion of a radial arrangement.

His first species is *Astrocyathus geinitzi* which he bases on the type figured by Geinitz (Dyas, pl. XX fig. 17) as *Calophyllum profundum*. Geinitz's form, however, is now referred to the *Cyathophyllum profundum* of Germar, and united with *Polycoelia donatiana* King as *Polycoelia profunda*. Ludwig's illustrations, however, do not show the four-fold arrangement of the primary septa (plate L) while the form which he figures as *Tetraphyllum profundum*, and to which he refers Geinitz's figures 15 & 16, does show that cross-shaped arrangement of the primary septa, though he figures 6 septa in the counter and 5 in the cardinal quadrants. Geinitz too, (pl. XX) figures 6 septa in one of his quadrants and the barest indication of a 6th in the opposite quadrant. This is an irregularity similar to the one found in the Mongolian species. In the text Geinitz refers to the fact, that the total number of septa ranges from 24-26, of which the four primary are ranged in a cruciform manner, while the quadrants have from 5 to 6 secondaries. In the longitudinal section fig. 17, he shows a few irregular tabulae. It is this form which Ludwig makes the type of his *Astrocyathus geinitzi*, but the cross-section which he gives, shows the accelerated counter quadrants with 7 septa in each, while the cardinal quadrants have only 3. In his description he states that there are no tabulae present. He further uses the broadened base of attachment as a specific character, a feature, however, that cannot be given much weight. On the other hand it is very evident that the septal arrangement in his *Astrocyathus geinitzi*, is essentially that of *Gerthia angusta* (Rothpl.), except for the fact, that in the latter the 4 primary septa are strongly thickened, while some of the secondary ones are slightly thickened. This is of course a feature of specialized development, and as is usually the case, the septa in the young are not thickened. Hence it is not at all unlikely that Ludwig's *Astrocyathus geinitzi* is congeneric with *Gerthia angusta*.

Ludwig's genus was never characterized, but the name was indiscriminately applied to all forms with apparent hexameral septal arrangement, that indeed being the chief characteristic of his genus. Thus that term is best discarded entirely, and *A. geinitzi* Ludwig, if it is a well characterized species, may be referred to a primitive form of *Gerthia*.

***Gerthia? sulcata* (Hinde)**

Plate I Fig. 4.

1890. *Plerophyllum sulcatum* Hinde. Geological Magazine, N. S., Dec. III, Vol. VII, page 197, Pl. VIII
A figs. 2-2a.

Hinde described a fragment of a cylindrical corallum from the Carboniferous (Permian?) of Irwin River, Victoria district Australia, as a second species of his genus *Plerophyllum*. It is evident, however, that this species cannot be referred to the same genus as the type species *P. australe*, since its primary septa only are enlarged and arranged in a cruciform manner. This and the general character of the coral rather suggest its affinities with *Gerthia angusta* (Rothpletz) of the Permian of Timor, and it is here provisionally, at least, placed in that genus. Hinde's original description is as follows.

"Corallum curved, approximately sub-cylindrical, showing in the upper portion repeated renewals of growth. The only specimen, which is imperfect, is 40 mm in height and 11 mm in diameter. There are in all 28 septa, of which 4 are prominently developed and the others are subequal. The cardinal or dorsal septum [more probably the counter] is large. Between it and the alar septa there are on one side 7, and on the other 8 smaller septa, whilst the large counter-septum [more probably the cardinal] has between it and the alar septa four smaller secondaries on one side and five on the other. The septa are about 1 mm apart. They are of precisely the same character as in *P. australe*, and they are similarly enclosed and consolidated by stereoplasm, so that in a transverse section of the lower portion of the coral the individual septa can only be recognized by their median lamellæ.

"The outer surface in this species has well-marked longitudinal ridges and furrows about half a millimetre in width, which appear to be quite independent of the septa [these are really the septal grooves and there is no reason to believe that they do not correspond in all cases to the centers of the septa as they do in all other corals].

"There is only a single example of this species in the collection. From *P. australe*, it is readily distinguished by not having more than four prominent septa and by the different characters of the outer surface."

It is quite evident that the orientation which Hinde assigns to this coral is an arbitrary one, since he does not consider that the septal grooves, which are very numerous according to his illustration (pl. VIII A fig. 2), have any relation to the septa. There can be no reasonable doubt, however, that as in all other cases, these septal grooves represent the centers of the septa, and we may conclude from their great number, that tertiary septa are present within the ring of stereoplasm which forms the thickened wall of the corallum. Hinde gives the number of septa as 28, but according to his illustration, there is approximately double that number of septal grooves.

Since there is no justification, in the arrangement of the septal grooves, for the orientation given by Hinde, we may feel at liberty to reverse this, so far as the cardinal and counter septa are concerned. If that is the true orientation, then the counter quadrants are the accelerated ones, as is the case with all related corals so far known. If Hinde's designation were correct, these corals would have to be placed in a distinct family, one in which the cardinal quadrants are the accelerated ones.

No dissepiments are indicated in Hinde's figure, although the wall is greatly thickened on the inside by the formation of stereoplasm of dissepimental aspect. No reference is made to tabulæ, and none are indicated in the illustration, so we may conclude that they are absent. If then we are correct in reversing the orientation, this species presents all the characters of a *Gerthia* and must be referred to that genus.

Family **STREPTELASMAIDAE** (Grabau emend.)

(This Volume, Fascicle I, p. 28)

Genus **BRADYPHYLLUM** Grabau (gen. nov.)

cf. 1922. *Heterelasma* Grabau This volume Fascicle I, p. 41, Pl. I, figs. 14 a, b.

Simple, streptelasmoid corals, forming straight or slightly curved cones, and, in the typical form, very gradually expanding. The radial arrangement of the septa is early acquired, the septa mostly reaching the center, where they are united by stereoplasm as in Devonian *Stereolasma*, of which they may possibly be derivatives. There is, however, no distinctive columella formed, but the solid center is due chiefly to the strong thickening of the septa themselves and to their lateral junction. Counter quadrants always accelerated even in the young, but alar pseudo-fossule not well-marked. The principal septa are, however, indicated by the costal grooves. In the adult, the cardinal as well as the counter septum become yoked, by strong dissepimental bars, to the adjoining secondaries, and both tend to become more or less aborted, with a production of a cardinal as well as a counter fossula. It is this

characteristic of the two primary septa, as well as the thickening of the secondaries, which forms the distinctive character of this genus.

GENOTYPE: *Bradyphyllum bellicostatum* Grabau. Middle Carboniferous, China.

In the first fascicle of this volume page 41 (pl. I, fig. 14 a b) I have discussed the *Hadrophyllum edwardsianum* of De Koninck, and proposed for it the generic name *Heterelasma*. This name, however, had been preoccupied for another type of coral, and it appears now as if this species may be an early representative of the genus *Bradyphyllum*, characterized by the partial abortion of the counter, as well as the cardinal septum. There is, however, no yoking of these primary septa to the secondary ones, and the quadripartite arrangement of the septa is still marked, with an indication of the alar pseudo-fossulae. From De Koninck's illustration it would appear that the number of secondary septa in the cardinal quadrants is at least 5 if not 6, while the number of secondary septa in the counter quadrants is 7 on one side and 8 or more on the other. The tertiary septa are all well-developed, and sometimes have almost half the length of the secondaries. It is not possible to determine, from De Koninck's figure of the calyx, whether there is any stereoplasmic thickening of the early part or not, nor any thickening of the septa themselves. In like manner, it is not ascertainable if dissepiments are present, though we may assume that they are. Externally the coral very much resembles our form, and agrees fairly well in dimensions, though on the whole it is smaller, being only 15 mm in height. The diameter of the calyx is given by De Koninck as 9 mm, agreeing thus fairly with our smaller specimens, but the calyx in De Koninck's form has a depth of 6 mm, or more than $1/3$ the length of the corallum. No such depth is indicated in any of our corals.

Carruthers (Geological Magazine N. S. Dec. 5, Vol. 5, page 25 et seq. 1908) has referred to *Hadrophyllum edwardsianum* of De Koninck as an immature form of *Zaphrentis omaliusi* E & H. He says (page 27) "An examination of his (De Koninck's) figured specimen showed that it was much weathered; to this fact, the unusual depth of the epithecal ribbing is due as also the presence of a small median groove down the center of each of the ribs, a fact to which De Koninck drew attention in his description. This latter character is not, however, of any specific value, but may be found in any much weathered *Zaphrentis* coral".

Carruthers seems to labour here under a misapprehension, provided of course De Koninck's figure gives the true conditions in his species. Carruthers says that a common and remarkable feature is the development of a counter fossula, through a slight enlargement of the two interseptal chambers on each side of the counter septum in *Zaphrentis omaliusi*, a character "almost always present in some degree in

the young stage of growth in the normal example of the species, and often persistent throughout. This counter fossula is proportionately longer than the cardinal fossula, but unlike the latter, of course never shows any appearance of young septa at its base''.

This feature cannot be regarded as a true fossula, nor can we even consider it a pseudo-fossula, since these are not normal areas of increment in growth. In the case of De Koninck's *Hadrophyllum edwardsianum*, there is indicated a true abortion of the counter septum, which is distinct from the slight enlargement on either side of the counter septum found by Carruthers in *Zaphrentis omaliusi*. Nor can this be considered a primitive feature, for abortion of a septum is always a specialized character. In Carruther's figures of *Z. omaliusi*, the characters shown in De Koninck's species are lacking, though in one of his illustrations (pl. IV, fig. 6), the counter septum, there shown at the top of the figure, is either shortened or accidentally broken. If the former, there would seem to be an approach to *Bradyphyllum*, but the peculiar juncture of the septa would place *Z. omaliusi* in the genus *Hapsiphyllum*, rather than in the present genus. In *Z. omaliusi*, tabulae are developed, but these are apparently absent in De Koninck's as well as in our species (see further under *Hapsiphyllum*).

***Bradyphyllum bellicostatum* Grabau (sp. nov.)**

Pl. II, Figs. 11 a-c, 12 a-c, 13, 14-16, 17, 18 a-c.

Corallum slender, conical, rarely more than faintly curved, more often with one side nearly perpendicular and the other gently arched. Sometimes, however, irregular constrictions occur. The rate of enlargement is a very regular one, and such as to produce a diameter of 11.4 mm, from an apical flattening 2.3 mm in diameter, in a length of 23.6 mm, or, on the average, 1 mm in 2.6 (Pl. II, Fig. 14.) The epitheca is apparently thin but somewhat wrinkled, but the most striking feature is presented by the very deep, relatively broad costal grooves. The ridges separating them are very pronounced and frequently rather coarsely cancellated by growth-lines which render them nodulose in appearance. By these ridges the principal septa are usually readily located, and it is seen that there is considerable variation in the position of the cardinal septum, this being in some individuals on one side of the corallum, in others on the concave side, and in still others on the convex side. Both tertiary and secondary septa are present or are indicated by costal grooves, but the tertiaries are as a rule very short, and often scarcely detectable in transverse section. The counter quadrants are greatly accelerated, the number of their septa being commonly half again as many as in the cardinal quadrants.

The calyx (Pl. II, Fig. 17, Cat. 1573) is apparently of moderate depth, though no extensive observations could be made, while the sides descend more or less abruptly.

The fossula is well marked, flanked by prominent converging septa, of which there are three in each cardinal quadrant. The alar septa are weakly developed, and they and the septa of the counter quadrants are flexuous. The first pair of counter laterals is apparently prominent, while between them, the counter septum seems to be shortened to produce a counter fossula. However, these facts are not ascertainable with precision, since the calyx is somewhat imperfect. The dorso-ventral diameter of this specimen is 8.4 mm, while its length is somewhat over 15.5 mm. The cardinal septum is located on the concave side or nearly so.

In the apical portion of this specimen, diameter 2.9 mm, the septal arrangement is somewhat irregular, with apparently only a single secondary septum in each cardinal quadrant and 2 in each counter. The interseptal loculi are nearly filled with stereoplasm, though a 'tear-drop' cavity remains in the center of most of them.

Another young individual (Cat. 1571), shows the 14 septa with a diameter of 2.5 mm. All of them are sub-radial, the central part being formed by a mass of stereoplasm, which also greatly thickens the septa. Of the 10 secondary septa 2 appear to belong to each cardinal and 3 to each counter quadrant. The cardinal septum here is located upon the side.

In a 3rd specimen (Pl. II, Fig. 12, Cat. 1568) the early stage (Fig. 12 c) at a diameter of 3.7 mm, shows 2 secondaries in the cardinal quadrants, the second one of which is short. The cardinal septum itself extends nearly to the center and apparently meets the counter from the opposite side. The alar are next in length, and there are three secondaries in each counter quadrant, more or less adhering into a group. The entire central area is filled with stereoplasm, and the septa are much thickened by it. The cardinal septum in this case is upon the side, though slightly nearer the concave than the convex surface.

The length of the specimen, the two ends of which are cut, is still nearly 19 mm. The larger end (Pl. II, Fig. 12 b), has a diameter of 8.7 mm, and is sub-circular. The cardinal septum is short, being less than half the length of the others. The counter, opposite it, seems to be entirely aborted. The two counter-laterals instead are yoked by a strong cross-bar, which is as thick as the septal ends. There is a minute point in the center of this bar on the inside, occupying the place which the counter septum should occupy, and this may be the remnant of it. There is thus a distinct counter fossula opposite the cardinal fossula. There are 10 strong septa between the cardinal and the yoked group which, as stated, appear to represent the 1st

pair of laterals, thus making 11 in all between the counter and cardinal on each side. The septa are longer on the left hand side which is the convex side of the corallum, for as stated, the cardinal and counter are upon the uncurved sides. On the concave side they decrease steadily towards the 6th septum which is essentially in the middle of the concave side and is the shortest, whereas the corresponding one on the left side is one of the longest, the remaining septa in the left counter quadrant decreasing progressively. This is, however, purely a matter of conformity to curvature, for these opposite septa do not constitute the alar septa, the position of these being well indicated by the costal grooves. From them it appears, that there are only 3 secondaries in the cardinal quadrants and 7 in the counter. The septa are all wedge-shaped, thick at their junction with the epithecal wall, where the thickness may reach 0.6 mm, which is also the average amount of thickening of the wall itself. Inwards the septa taper to blunt points. Tertiary septa are indicated by the septal grooves, but do not project beyond the thickened wall. In this section endotheal tissue appears to be entirely wanting.

A specimen of average character, sectioned at several places, shows very distinctive features. A portion of this is represented in Pl. II, Figs. 11a and 11b. The length of this portion is 7.3 mm. Its dorso-ventral diameter at the larger end is 10.6 mm and at the smaller 8.1, mm, giving a rate of tapering of a little more than 1 in 3. The cardinal septum is well indicated by the costal grooves, and is situated on the convex side of the curvature.

In the larger section (Pl. II, Fig. 11b), the cardinal septum is short and yoked to the lateral septa by strong, slightly convex, transverse bars, beyond which it does not project. There are 3 secondary septa in the cardinal quadrants, all of them slightly thickened, towards the center, in a club-shaped manner. They are in contact, and united inwardly, by their stereoplasmic sides, into a single group on either side, with which the alar septa are also united, these being essentially of the same character as the 3 secondaries. In the counter quadrant there are 7 secondaries, the 1st pair terminating in a point, while others are thickened, but not to the same extent as seen in those of the cardinal quadrants. The 4th, 5th & 6th are most thickened, and join in a group, the 7th touches the alar septum. The others are free, or nearly so. The counter septum is slightly longer than the others, but does not reach the center, which for a space, approximately 2 mm in diameter, is free from septa. The counter septum tapers regularly, and midway of its length it is joined, by two strong dissepimental bars, to the 1st pair of secondaries. These dissepimental bars, like that terminating the cardinal septum, are much thicker than the ordinary dissepiments of which at least 2 rows are seen in the section. The tertiary septa, while indicated by the costal grooves, do not project beyond the calicular wall.

There is here a slight variation from the conditions of the specimen represented in Fig. 12 (Cat. 1568). In that specimen, which is much smaller, the counter septum has become wholly aborted, and the cardinal septum is free. In the present specimen, the counter septum, though yoked, is present, and the cardinal septum is bounded by the yoking dissepimental bars. It is possible that the section of the upper end of the specimen (No. 1568) is through the calyx, while the section of Fig. 11b is through the corallum itself.

In the smaller section (Pl. II, Fig. 11c), the cardinal septum meets the others in the center and is not yoked. It is thinner than the secondary septa, except the last pair. The counter septum, too, extends essentially to the center, but the alar fall somewhat short of it. There is no yoking seen in the counter septum, and the counter secondaries all extend, in essentially radial manner, into the central area. This is a solid mass of stereoplasm about 5 mm in diameter, and formed primarily by the lateral contact of the much thickened septa. Dissepiments are very infrequent in this part.

A section several mm higher than the one shown in Fig. 11b, has a diameter of 10.8 mm (Pl. II, Fig. 11d). The bridge of the yoke of the cardinal septum is seen on one side only, while apparently on the other it is extended in line with the septum. One of the alar septa, or the 4th septum from the cardinal, is somewhat shorter on one side (the right) (left in figure*) than the 3 preceding secondary septa, but like them is thickened. The seven secondary septa of the counter quadrants are very nearly alike, all thickened towards the interior, and joining by their sides, to form a thick irregular stereotheca around the center, which is mostly free from septa, though most of the longer ones project into it. The counter septum is long, reaching into the center. Dissepiments are few, and tertiary septa do not project beyond the outer wall. The counter yoke is still present but has moved more towards the center.

Another section, about 5 mm higher (Pl. II, Fig. 11e), has a dorso-ventral diameter of 11.5 mm. The cardinal septum here again shows its yoke, but this has become very thin, as has also the terminal portion of the cardinal septum. The 3 secondaries of the cardinal quadrant unite into a group. The alar is free, but has the 7th secondary of the counter quadrant joined to it. The other 6 secondaries of the counter quadrants are free on the left side, and thickened medially, while those on the right are tapering and have their ends more or less joined by dissepimental bridges. Tertiary septa are still buried in the wall; dissepiments sparingly developed.

A number of cross-sections of another individual show, for the most part, radially arranged septa. The first of these (Pl. II, Fig. 18a) has a diameter of 6.6 mm. There

* The section is reversed.

are 22 septa, all of which are thickened by secondary stereoplasm, this thickening being slightly more at their inner ends. In this section, it is entirely impossible to determine the primary septa. (The same is true of the section in Fig. 20). The tertiaries are indicated merely by the septal grooves. Dissepiments sparingly developed. The second section (Pl. II, Fig. 18 b), has 23 septa, radially disposed, with a diameter of 7.7 mm. Tertiary septa, in some cases project slightly beyond the calicular wall. In the center, where the principal septa are somewhat thicker, they all join more or less, with secondary reinforcement of stereoplasm. From 2 to 3 rows of delicate dissepiments are recognizable.

A third section (Pl. II, Fig. 18 c), has a diameter of 8.7 mm. It also has 23 septa. In this section the cardino-counter axis is recognizable. One of the principal septa extends to the center in a very thin line, and is apparently yoked near its middle to the adjoining septa. This is probably the counter septum. The septum opposite it is interrupted, its inner thin end being separated from its outer thicker end, which is yoked by a dissepimental bar to the septum on either side. The abortion of the inner end would produce the characteristic structure seen in the adult, as above described (cf. Fig. 11b, Pl. II), while the abortion of the thin counter septum would produce the counter fossula. If these determinations are correct, we appear to have six secondary septa on one side, and 7 on the other. In this section too, the septa are more or less united in the center by stereoplasm, and a few rows of delicate dissepiments occur. The tertiary septa are indicated, in some cases, as very slight projections between the others.

Longitudinal Section: A longitudinal section of a characteristic individual (Pl. II, Fig. 13), shows the interior to be of very simple structure. Tabulae are entirely absent, and the septa apparently meet in the center in a solid mass, produced by the stereoplasmic thickening of the septa themselves. The dissepiments are distant; and comparatively few, and no other endothecal structures appear to be developed.

HORIZON & LOCALITY: This appears to be a rather common form in the Moukou formation of Middle Carboniferous age at Moukou, Fu-I-Hsien, Kansu. Collected by P. L. Yuan. Geological Survey of China, Cat. 1567 to 1574, 1587 etc.

***Bradyphyllum obscurum* Grabau (sp. nov.)**

Pl. VI, Figs. 4 a-d. 5 a, b.

Corallum small, rather stout, slightly curved and roughly horn-shaped. Original length about 25 mm, but the basal part imperfect. Calyx roughly circular, with a diameter of 16 mm. Exterior with the septal grooves faintly marked; both specimens

very strongly weathered. Growth-lines and wrinkles occasionally marked. Cardinal septum situated more or less directly on the side of greatest curvature. A section of our larger specimen, (Cat. 1589, Pl. VI, Fig. 4 b.) was made between 5 and 6 mm above the base. The dorso-ventral diameter is 8.4 mm., the transverse slightly less. The section is imperfect. The septa are essentially radial, reaching nearly but not quite to the center, except the cardinal septum which reaches only half way to the center. There are 22 septa besides the cardinal, showing an irregularity of development. On either side are two other septa which are slightly shorter than the others, and these appear to be the alar septa, though that is not absolutely determinable. If they are, then there are 4 secondaries in the right cardinal quadrant, and 5 in the left. This leaves 5 septa for each counter quadrant. On the right hand side, these are still united at their inner ends, but on the left they are free, as is also the counter septum, which is of the same character as the others. All the septa are greatly thickened by secondary stereoplasm, and tertiary septa, though short, appear to be present in most of the interspaces. There seems to be a considerable amount of dissepimental tissue, but the preservation does not permit of exact determination of this point. The very center of the corallum seems to be free from septa and apparently filled with matrix.

A second section taken several mm higher (Pl. VI, figs. 4 c reversed), has a diameter of 8.8 mm. Here too, the septa are all radial, but they are all shorter, leaving a larger central area filled with irregular material, similar to that filling the interspaces between the septa, and apparently a coarse granular matrix. The septa are all thickened and wedge-shaped, the cardinal and counter being more thickened and triangular than the others, and also shorter, especially the cardinal. What are taken to be the alar, are also shorter, and here again we find 5 secondary septa on the left, and 4 on the right, in the cardinal quadrants, with 5 secondaries in each counter quadrant. Tertiary septa are still faint, but appear to be present. Again there appears to be some dissepimental tissue, but this cannot be positively ascertained.

A section 9 mm higher on the cardinal side, but only 3.5 on the counter (Pl. VI, Fig. 4 d), has a diameter of 11.5 mm, being essentially circular. The septa all fall short of the center, leaving a circular free area about 4 mm in diameter, which in this section is seen to be filled entirely with matrix, as are also the interspaces between the septa. The septa of the cardinal quadrants are still much thickened, those of the counter, however, are more slender. All of the septa taper regularly to their termination. The cardinal septum is a little more than half the length of the others, and is stout, but the counter septum is only slightly shorter than the others, rigid and slender like the secondaries, only somewhat more so. The alar are scarcely different from the secondaries of the counter quadrants, though a trifle shorter than these. They are, however,

more slender than the secondaries of the cardinal quadrants. There are still 4 secondaries in the right cardinal quadrant and 5 in the left, with 5 secondaries in each counter quadrant. The tertiary septa now project freely for varying distances beyond the rather thick wall, which averages 1.3 mm in thickness. It appears irregularly vesiculose, but no definite vesicles are determinable, though it would appear that there are 1 or 2 rows of marginal dissepiments. The septa, however, extend entirely to the outer wall.

The second specimen (Cat. 1609) (Pl. VI, fig. 5) was sectioned 5.6 mm above the base. The section has a dorso-ventral diameter of 6.8 mm and a transverse of 6.2. (Pl. VI, fig. 5a). The septa are radial and nearly, if not quite, reach the center. There are 15 stout septa on one side and 12 more slender ones on the opposite, or 27 in all. This is a greater number than that seen in the other specimen where there are only 23 septa. In the present case, only the cardinal septum which is shorter than the others can be determined with reasonable certainty, but because of the imperfect character of the septal grooves, and the similarity of the septa, it is not possible to recognize the alar septa. Tertiary septa seem to be well-developed in all the interspaces, being stout in the cardinal region and slight in the counter, where they sometimes adhere to the secondaries. Dissepiments are present but are rather irregular. There is a certain amount of grouping of the septa, but this is not sufficiently marked to permit ascertaining definite relationships. Two adjoining septa on the counter side are shorter than the others, and are bound together by a dissepiment. One of these is the counter septum.

A second section several mm higher, has diameters of 8.3 and 7.8 mm, respectively, the larger being the dorso-ventral. It is reversed. The septa are all more or less radial, the cardinal septum is less than half the length of the others and of wedge-shaped form and closely flanked by other wedge-shaped septa, which progressively increase in width outward. Despite the shortness of the cardinal septum, there is no distinct fossula or even pseudo-fossula, the cardinal appearing more as an enlarged tertiary septum between the slightly more distant, rigidly straight, and rather thick, flanking secondaries. The secondaries of the cardinal quadrants are mostly wedge-shaped, while those of the counter quadrants have the shape of nine-pins, thin and regularly swollen at, and in contact with, their inner half. There are 13 septa on each side between the cardinal and counter, but the number in each of the quadrants cannot be ascertained, since the alar septa cannot be located. The counter septum is swollen like the counter secondaries, but more strongly so, and its stem or peripheral part is also thicker, and near the periphery broadens out again.

Tertiary septa are well developed, being quite distinct in the broad interspaces of the cardinal quadrants, but less so in the narrow interspaces of the counter quadrants where they are also thickened like the secondaries. Dissepiments are not very numerous, but are present.

This species is stouter and shorter than the preceding one, and less elegantly formed. In the character of the septa, it is also markedly distinct, and the strong thickening of the septa obscures the structural feature much more than is the case in the more slender species. There is, however, essential agreement in the radial character of the septa, which is assumed at a very early stage, and in the free central space, and the slight development of the dissepiments.

HORIZON AND LOCALITY: In the Moukou Formation, believed to be of Moscovian age, at Moukou, Fu-I-Hsien, Kansu. (Locality 510). P. L. Yuan, Collected. Cat. 1585 & 1609.

The Genera *TACHYLASMA* Grabau, *PLEROPHYLLUM* Hinde, *PENTAPHYLLUM* De Koninck, *PLEROPHYLLUM* Gerth, *CRYPTOPHYLLUM* Carruthers, *OLIGOPHYLLUM* Pocta, and *UFIMIA* Stuckenberg.

Genus **TACHYLASMA** Grabau

1922. Palæontologia Sinica 1922 this volume Fascicle I, p. 24.

The septal arrangement in the young form of this genus is shown in Fig. 51 on page 41 of Fascicle I. This clearly shows its relationship to the *Streptelasmaidæ*. The 4 primary septa are fully developed, reaching nearly to the center, and the first counter secondary pair is equally well developed. The counter quadrants are accelerated to the extent of 2 secondary septa over the cardinal. The modification of this genus presents the following steps. The alar septa are thickened until they become club-shaped and the first pair of secondary septa in the counter quadrants is likewise thickened until it becomes nearly, if not quite, of the same size and shape as the alar. The counter septum retains its length in the primitive forms, but its thickening is very slight (*T. cha*). In another form (*T. elongata*) the chief modification above that shown in the preceding species, is the shortening of the counter septum. In both cases the number of secondary septa in the counter quadrants is 8, while that of the cardinal quadrants is 3 or 4. The cardinal septum in each case is aborted so that a distinct fossula is formed. As a rule the other secondary septa are but slightly thickened. It is only in the most specialized species described (*T. aster*) that this thickening of other secondary septa becomes pronounced. In the early

stages of this species the alar and the two first pair of counter secondaries are thickened, but in addition to this the counter septum is equally thickened, all five uniting in the center into a solid stereoplastic mass. The cardinal septum, however, remains thin (Fascicle I Pl. 1, Fig. 4), and in later stages continues in this manner, though it is not aborted to the same extent that is found in the other species. Certain of the other secondaries, both in the counter and the cardinal quadrants, are thickened, while others are left unthickened and shorter. Usually the second pair of secondaries in the counter quadrants are retarded, a marked difference being exhibited in this respect between this genus and *Gerthia*, where the second pair is thickened while the first pair is retarded. The two genera are, however, in agreement in that both have the first pair of septa in the cardinal quadrants retarded, while the second pair is more strongly developed. As we shall see presently, the chief distinction between *Tachylasma* and *Plerophyllum* lies in the fact that in the latter genus 5 septa are thickened. According to the original description by Dr. Hinde these are the alar, the counter, and the last two of the secondary septa of the cardinal quadrants, this quadrant being the accelerated one. Gerth on the other hand, in his description of the species of *Plerophyllum*, reverses the designation, for according to him it is the counter septum which is aborted, and the first pair of secondaries in the counter quadrants, which is greatly thickened as well as the alar and the cardinal. This would bring *Plerophyllum* in harmony with the other types of this series and make the counter quadrants the accelerated ones. If we accept this interpretation then the chief difference between *Plerophyllum* and *Tachylasma* lies in the fact that in the former genus the cardinal septum is equally thickened (Pl. I, Figs. 5 & 6), whereas in *Tachylasma* it is aborted. For description of species of *Tachylasma* see below, and Fascicle I.

Genus **PLEROPHYLLUM** Hinde

1890. Geological Magazine N. S., Dec. III, Vol. VII p. 195.

The generic name *Plerophyllum*, was proposed by Hinde in 1890 for a coral which he believed to be identical with *Pentaphyllum* De Koninck (1872 page 58) described by that author in 1872. The name *Pentaphyllum* was however preoccupied in 1821 for a genus of Coleoptera. Moreover, Hinde's genus is more definitely characterized than De Koninck's, who stated that the main characteristic of his genus *Pentaphyllum* was the possession of 5 prominent septa. In his figure of *P. armatum* (1872 pl. IV, fig. 8a) six such septa are shown, while in the only other species included by De Koninck in his genus i. e. *P. caryophyllatum*, there are only 4 prominent septa. This may be referable to *Gerthia*.

The following is the generic characterization of *Plerophyllum* as given by Hinde. „Simple, conical, turbinate or subcylindrical corals, with deep calices. There are usually 5 prominently developed septa, (in some species only four), which reach nearly to the center of the calice; the other septa are sub-equal. In the species with 5 prominent septa, the cardinal septum is small and is bounded on either side by a large septum, and the remaining 3 large septa represent the counter and alar septa. Where only 4 prominent septa are developed, one of them constitutes the cardinal septum. [This type cannot be regarded as congeneric with the other one, and is here referred to *Gerthia*]. Both large and small septa exhibit a distinct, opaque, median lamina, which begins within the substance of the wall, and is inclosed by successive layers of stereoplasm, so that in the lower portion of the coral the septa are laterally in contact, and the interocular and central areas are filled up with solid tissues. The wall of the coral is thick, and consists apparently of the coalesced parietal margins of the septa with an outer epithecal layer. The outer surface exhibits either shallow annulations of growth with fine concentric striae, or longitudinal rugae, or more rarely, spinous projections.”

The typical species of *Plerophyllum* is *P. australe* Hinde (Pl. I Figs. 5 & 6). This comprises straight, conical, or curved corals about 30 mm in height, and from 10-13 mm in diameter at the summit. Hinde states distinctly, that the cardinal septum is short, with a prominent septum on either side. The two alar, and the opposite or counter-septum, according to Hinde, are equally strengthened. If Hinde is correct in this determination, and he appears to be very positive in the matter, we have here a coral which is very distinct from the others so far noted, and which does not even belong to the *Streptelasmaidæ*, for it represents a type in which the cardinal quadrants are accelerated so that they have 6 septa, whereas the counter quadrants have only 5. Another very strange character in this coral, as interpreted by Hinde, is the fact that the last-formed pair of secondary cardinal septa is larger than all the others. This is such an exceptional thing in coral morphology, that one is led to question the accuracy of Hinde's interpretation in this case. It would be a far more normal feature, if the two large secondary septa were the first pair of counter secondaries, the counter septum itself being shortened, while the cardinal septum opposite to it is also greatly strengthened. Moreover, this interpretation would make the counter quadrants the accelerated ones, and place this coral in harmony with the other members of the family STREPTELASMAIDÆ. This indeed is the interpretation which Gerth puts upon this genus. Thus in his *Plerophyllum radiceforme* (our Text-Fig. 5c p. 28) from the Permian of Timor, he distinctly shows the cardinal, alar, and 1st pair of counter secondaries strengthened, so as to form the 5 main septa, while the counter septum itself is short.

The counter quadrants too are accelerated, containing 6 septa on one side and 7 on the other, while the number, in the corresponding cardinal quadrants, is 4 and 3 respectively, the second in each case being the longest, while the last-formed is the shortest.

It is possible that Hinde based his determination of the orientation of the corallum on the fact, that he considered the aborted septum is normally the cardinal one, since this abortion gives the effect of a fossula, indeed, has all the characters of a fossula, except that it is not the combination of two pseudo-fossulæ, or areas of maximum increment, as is the case with the true fossula formed by the abortion of the dividing cardinal septum. But in these highly specialized corals, the abortion of the counter-septum is not an uncommon thing. Indeed, there are species in which both the cardinal and the counter septum are aborted, thus leaving a fossular gap in each case. For description of species of *Plerophyllum* see below.

Genus **CRYPTOPHYLLUM** Carruthers

1919. Geological Magazine Dec. IV, Vol. VI, No. 664 p. 436 *et seq.*

If we follow Gerth and reverse the orientation of the corallum of *Plerophyllum* this type becomes very similar to the genus *Cryptophyllum* of Carruthers. Indeed Carruthers considers that the main difference between his genus and Hinde's is this reversal of orientation. In Carruthers's typical species (*C. hibernicum*) from the Carboniferous Limestone of Ireland (Tournaisian and Viséen), the five principal septa are not thickened medially but are tapering. They are, however, much longer and proportionately much larger than the other septa. In his study of the development of this coral, from serial sections, Carruthers finds a most remarkable fact, namely that the counter septum is not so much aborted during the progress of growth, but its actual appearance is retarded, until long after the 1st pair of secondary counter septa, the so called counter-laterals of his designation, have appeared. (Text-Figs. 7, 1-9). It has been repeatedly shown that, in such highly accelerated corals as *Lophophyllum*, the first pair of counter secondaries appears almost simultaneously with the four primary septa, or so soon after them, that the earliest section which it is possible to make of their tips, already shows their presence, with the result, that the septation of the young appears to be hexamerall. It is, indeed, on the evidence of such sections, that Duerden and others have based their conviction that the primary septal plan of these rugose corals is hexamerall. As we have shown in the previous monograph, by reference to Brown's work, this conclusion is erroneous, and has

arisen merely from the fact that the studies of its proponents were made on very late Palaeozoic, and therefore on very highly accelerated types, whereas the development of the geologically earlier types clearly shows the tetrameral arrangement to be the primitive one, and the apparent hexameral character, the result of extreme acceleration of the counter quadrants, which indeed show acceleration in all the members of the family.

Cryptophyllum falls in very readily with this arrangement of the structures of the parts, the acceleration here merely being extreme, or perhaps it would be more correct to say, that to the normal acceleration of the counter quadrants is superadded the retardation of the counter septum. As shown in the sections on p. 68 of fascile I a similar type of acceleration affects the first pair of counter secondaries in the genus *Cyathaxonia*, only here these appear after the cardinal and counter septa have formed, but before the alar septa have made their appearance. Such differential acceleration is of course to be expected, and if conclusions regarding the phylogeny of the group are based upon the ontogeny of such specialized forms, erroneous results must be expected.

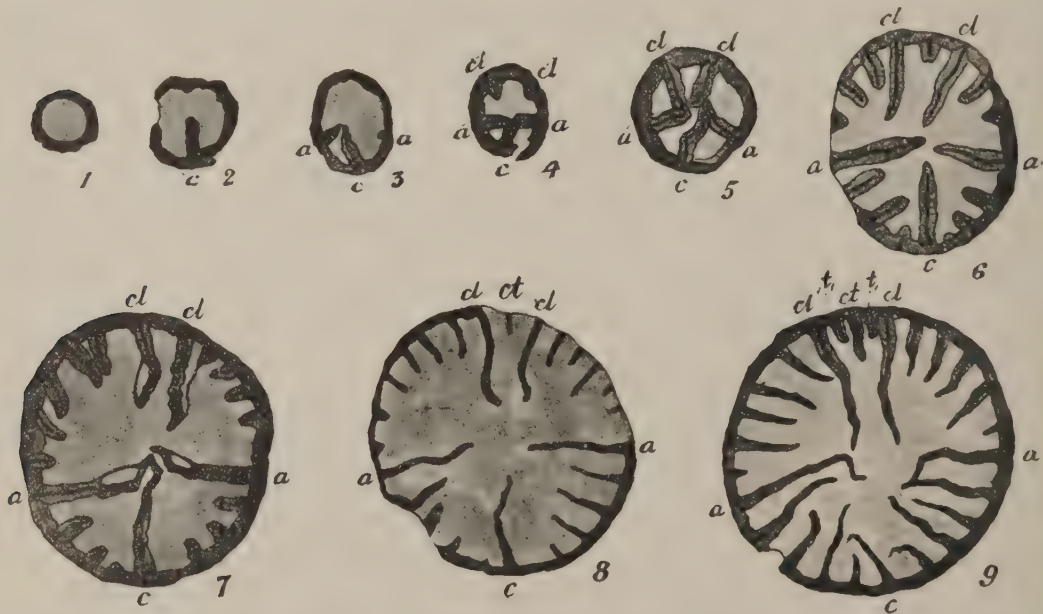


Fig. 7. *Cryptophyllum hibernicum* Carruthers. A series of cross-sections from several individuals showing the stages in development (After Carruthers). (1) epithelial ring only; (2) cardinal septum developed; (3) beginnings of alar septa; (4) beginnings of counter laterals (*cl*) or first pair of secondaries of counter quadrants; (5) five-septal stage; (6) the counter septum and additional secondaries are developed; (7) section of retarded individual in which the counter septum is not developed; (8) another adult in which the counter septum has appeared; (9) Section of accelerated individual in which the counter septum occurs and a pair of tertiary appears next to it. The sections have been relabeled as follows; *a, a*, alar septa; *c*, cardinal septum; *cl* counter septum; *cl*, counter laterals or first pair of secondaries in counter quadrants.

A curious fact is shown by the serial cross-sections of *Cryptophyllum*, namely that the cardinal and alar septa are the first to appear, so that at certain stages there are only 3 septa which meet in the center, the fourth, the counter, being absent by retardation. (Fig. 7,₃₋₄). Then the two counter lateral or first pair of counter secondaries make their appearance as mere ridges upon the side of the epitheca, subsequently reaching the other three, and making the primitive pentaseptate stage. The counter septum, if it appears at all, which seems not to be the case in some individuals, arises only after the other secondary septa have appeared or at least most of them. In rare cases a pair of short tertiary septa subsequently arise on either side of it, but the counter septum is never as long as the other septa. This single pair of tertiary septa is the only one to appear. (Fig 7,₉)

The only species of *Cryptophyllum* so far described is *C. hibernicum*, from the Tournaisian and lower Viséen of Ireland, though it has also been recorded from the *Dibunophyllum* zone of the Viséen. This is a small coral averaging an inch or less in length and usually of a tortuous mode of growth, there being frequent constrictions. The septa are not thickened, but taper and are wavy at their inner ends. The five septa (cardinal, alar, and two counter laterals), appear as stated under the genus, but the counter septum does not appear until several of the other secondary septa have arisen. Including the 1st pair, there are 6 secondary septa in the counter quadrants, and 4 in the cardinal. In one of the sections shown by Carruthers, (Text fig 7,₇) all 6 have appeared in the counter, and 3 in the cardinal, without the appearance of a counter septum, while in another section (Text-Fig 7,₈) it appears with 4 secondaries in the counter quadrants (including the 1st pair) and 3 in the cardinal. Thus it would seem, that in some cases the counter septum is so retarded, that it does not appear at all. In other cases, where the counter septum appears earlier, a pair of tertiary septa may also arise on either side, but this is the only pair of this series recognized. Stereoplastic thickening of all the septa occurs below the calyx, but this is more or less uniform throughout. A few irregular tabulae are present.

Even if we consider that Hinde was mistaken in the orientation of the septa of *Plerophyllum* and hold that the two long septa on one side are the first counter secondaries or counter laterals (C. L.) and the short septum between them the counter instead of the cardinal, the two genera *Plerophyllum* and *Cryptophyllum* must be considered distinct. Of the two the latter seems to be the most specialized which is remarkable since it occurs primarily in the Tournaisian, and apparently does not extend above the Viséen. We have no early sections of the type species of *Plerophyllum* (*P. australe* Hinde), but according to all indications the counter septum (if the shorter one is the counter) is not as retarded in origin as it is in *Cryptophyllum*

but apparently is one of the original four primary septa, with the first pair of secondaries out-stripping it in development. Moreover the 5 resulting principal septa are thickened at their inner ends instead of tapering as in *Cryptophyllum*, although if this were the only difference it would have to be considered a specific rather than a generic one.

P. australe Hinde is thought to be of Permian age which would give us the phenomenon of a less specialized type in the younger formation. If that is the case then *Cryptophyllum hibernicum* must be considered a highly specialized lateral branch of the Streptelasmoid stem. The second species described by Hinde does not belong to this genus and has been referred to the Genus *Gerthia* (*ante*, p-29)

Genus **OLIGOPHYLLUM** Pocta (1902)

Pl. VI, Figs. 7-9, Text Figs. 8,9.

1902 Pocta in Barrande, Systeme Silurien du center de la Boheme Vol. VIII part 2, p. 192.

This genus was created for two corals from the Lower Middle Devonian or Givetian of Bohemia, these being described as *O. permirum* Pocta and *O. quinquesseptatum* Pocta, the latter being the genotype. A third species which belongs here, is *Orthophyllum simplex* Pocta from the same horizon, described at the same time by Pocta, together with other species of *Orthophyllum* from the Silurian and Lower Devonian. Pocta places the genus *Oligophyllum* in the family *Polycoelidae*, which is, however, a misinterpretation of the true character of *Polycoelia*. As we have seen

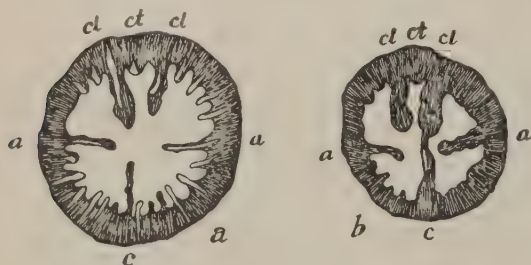


Fig. 8. *Oligophyllum quinquesseptatum* Pocta (after Pocta, with lettering modified) much enlarged. a, Section showing cardinal and alar septa and well developed counter laterals with small counter between; b, another section nearer the base, the counter septum is feeble. Middle Dev. gr Doorce Bohemia. (a alar; c, cardinal, ct, counter laterals, ct counter)

that genus is characterized by the strong development of the four primary septa while the quadrants are as a rule equally accelerated. In the present case only 3 of the primary septa are strongly developed, together with the two counter laterals, while the counter septum itself (designated by Pocta the cardinal septum, which is most certainly erroneous) is aborted. Indeed this genus shows a remarkable similarity to *Cryptophyllum* Carruthers on the one hand, and *Plerophyllum* Hinde on the other. The corals

are simple, conical, more or less curved and not of very large size, Pocta states distinctly that the pinnate arrangement is not recognizable, the epitheca either being

absent, or else not showing the septal grooves, and this is borne out by his figure 8 & 9 on pl. 68. He says, however, of the septa "La disposition de ces dernieres est regulière. On reconnait l'endroit ou se trouvaient la cloisons principale, la cloison opposee et les deu cloisons laterales".

If his determination of cardinal and counter septum were really correct this type would be entirely distinct from all the other known primitive corals, for we would have to regard the two last-formed secondary septa of the cardinal quadrants as becoming most profound, whereas in all other corals it is the first-formed pair of secondary septa in the counter quadrants that is thus increased. In view of this fact I have no hesitancy in assuming that the orientation of Pocta's corals must be reversed, and I shall discuss them here on the basis of that assumption. The calyx in this type is very deep and the septa begin only at the middle height of the corallum or even below.

The most primitive species described is *O. permirum*. This is irregularly conical and has a height of from 18 to 25 mm, while the maximum diameter varies from 20 to 25 mm. In the type specimen illustrated by Pocta (pl. 68 fig. 8) the basal portion is broken away, hence no early sections showing the development of the septa could be made. This specimen also shows the epitheca entirely free from septal grooves, being marked only by growth-lines, though he says that these septal lines are very feebly indicated. The transverse section, which is about at the middle of the height, is figured on pl. 108 fig. 20, and is reproduced in our Pl. VI, Fig 7. It shows a very thick septal group on one side, joined by the two rather slender alar septa, while opposite is the barest indication of a very much reduced primary septum. This reduced septum Pocta calls the counter septum, and in this I consider he is quite correct. But, the thick septal mass opposite he calls the two lateral septa contiguous to the cardinal septum. The cardinal septum itself is indicated as a short projection from the center of this mass, in the middle of the section. Pocta states that at a little above the point of this section, the mass separates into two parts with a narrow interspace, the cardinal septum having entirely disappeared, and he would call these separated masses the greatly enlarged lateral septa contiguous to the cardinal, comparing them to the large septa in the other species.

Now this seems to me an impossible interpretation. In the first place it is inconceivable that, if the cardinal septum is indicated in the center of the corallum by a slight median projection, closely adjoined by two lateral septa, that a very short distance higher, the cardinal septum should entirely disappear and these two lateral septa alone remain. I would interpret this thickened septal mass as the cardinal septum alone but greatly thickened by the deposit of stereoplasm

on either side. Indeed that seems to be the only interpretation possible, for Pocta's section shows a thin median septum, apparently the thin continuation of the small projecting point, extending through the middle of the thickened mass toward the periphery, while the material on either side shows no septal centers, such as should exist if it represented two lateral thickened septa. (See our Pl. VI, Fig.7.) Instead it is merely a mass of stereoplasm of the same kind as that which thickens the outer wall, and with which it is continuous, and by which it is exceeded in thickness. The fact that at a little higher point above the section, there should be only these two masses of stereoplasm, with a space in the center, does not invalidate this interpretation, for it is perfectly conceivable that the stereoplasmic thickening on either side of the cardinal septum should, in the bottom of the calyx, actually rise above the level of that septum itself, and so produce the appearance of two parallel septa divided by a narrow vacant space. Such an interpretation I would consider far more rational than the abrupt disappearance of a principal septum, which, a moment before, extended to the center.

If this interpretation is correct, we have here a remarkable reproduction, in an adult corallum from the early Middle Devonian, of the early neanic characters of the Dinantian genus *Cryptophyllum*. In the illustrations of the early stages given by Carruthers for *Cryptophyllum hibernicum* from the Viséen of Great Britain we see that the 1st septum to appear is the cardinal, after which the two alar appear, the three joining in the center precisely as in the section of the adult *Oligophyllum permirum*. Here, however, a variation occurs. In *O. permirum* the older form, the counter septum appears as a short median projection which is quite in accordance

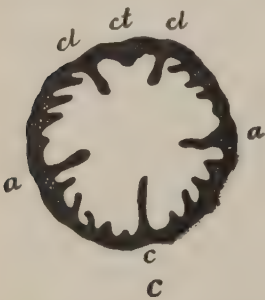


Fig. 9 *Oligophyllum simplex* (Pocta) Sections much enlarged, showing incipient counter septum. Mid-Dev. (g1) Bohemia, (after Pocta pl. 115 fig. 9).

with the normal development of the tetraseptate corals. In *Cryptophyllum* on the other hand, which is a highly accelerated form, as we have seen, the two counter laterals appear first and the counter later between them, this never developing to any length. As previously stated, this is the effect of excessive relative acceleration in the direction already indicated by other forms. This same stage in development is reached by the second species, *Oligophyllum quinqueseptatum*, which, so far as the long septa are concerned, corresponds entirely to a primitive stage of *Cryptophyllum* such as that illustrated in section 3 h, or 2 b, in Carruthers' diagram. (Text-Fig. 7-5) The only difference is, that in the Bohemian species, the adult has 6 secondary septa in the cardinal quadrants, and 4, or possibly 5 short ones in the counter, making a total of 5 or 6 in each counter quadrant, whereas in *Cryptophyllum* the number in the counter

quadrants is slightly greater and that of the cardinal slightly less. Finally in the species described as *Orthophyllum simplex* and illustrated on pl. 115 fig. 9 (our Text-Fig. 9) and which I consider belongs to the present genus, the cardinal and alar septa project halfway to the center, which is also true of the counter laterals, the counter itself being short and thick between them. In this species there are four additional secondary septa in the counter quadrants making 5 in all, and 5 secondary septa in the cardinal quadrants, thus showing equal acceleration.

Genus **UFIMIA** Stuckenberg 1895.

(Korallen etc. der Steinkohlenablagerungen des Ural und des Timan, page 184-185, Pl. II, fig. 2 & 3, Pl. III, fig. 3).

This genus was erected by Stuckenberg for a simple conical coral, somewhat curved, with a deep calyx of elliptical or irregularly rounded section. The cardinal and counter septa occupy the longer axis of the corallum and both are faintly developed. The others are of unequal length. In the genotype *U. carbonaria* Stuckenberg (Stuck. 1895, Pl. II, fig. 2) the costal grooves are well shown, and the septa reach part way to the center in the compressed calyx (in a section taken midway, fig. 2 c). The alar septa and the two counter laterals appear stronger than the others, there being 4 additional septa in the counter quadrants, making 5 in all, and 3 in the cardinal, while both cardinal and counter septa are shortened. In a still earlier section (fig. 2 d) the septa all seem similar and radial, except the cardinal, which is shortened. A section of another individual just below the calyx shows elliptical form, but the strengthening of the septa seems to be different, or else in this case the two principal septa are situated in the shorter axis. The alar are stronger and slightly thickened at the inner ends while the 1st pair of counter laterals does not differ much from the others, although these are the longest septa of the counter quadrants. The total number of septa in these quadrants is 7, the counter septum itself being short. The cardinal septum, however, is long, and there are two secondary septa in each cardinal quadrant. Both specimens illustrated are from the Ufa river and probably of Permian age. The tertiary septa are present in all the inter-spaces, but they are scarcely recognizable, except in the calyx, where the total number is 48. None of his sections show endothecal structures other than the septa, and no statement is made of their presence.

That this genus is related to *Tachylasma* is suggested by the character of the earlier sections, in which the development of the septa appears to be essentially that of the Chinese species, except that they never reach the strong development there shown.

The elliptical calyx however, which appears to be an original feature, the total absence of dissepimental tissue and the equalization of the septa in the upper part, distinguish it sufficiently, these principal septa being exert and very prominent in the calyx of *Tachylasma*.

Stuckenberg's species are, as stated, from the Ufa River, and are referred to as widely distributed in the Upper Carboniferous limestone of the Ural.

SUMMARY

We may summarize the preceding discussion of these specialized Streptelasmaidæ by separating them under a number of subfamilies and giving the diagnostic characters of each.

Subfamily **TACHYLASMAINÆ** Grabau (nov.)

Streptelasmoid corals in which the alar septa and the counter laterals are most strongly developed, and usually thickened in a more or less club-shaped manner. The cardinal septum is typically abortive and never strengthened. The counter is of variable length. Intrathecal tissue rare or wanting in primitive forms. More or less well developed in specialized species. Counter quadrants accelerated as in all the Streptelasmaidæ.

Genera at present recognized:

1. *Tachylasma* Grabau, Permian
2. *Ufimia* Stuckenberg, Carboniferous to Permian?

Subfamily **PLEROPHYLLINÆ** Grabau (nov.)

Streptelasmoid corals resembling the Tachylasmainæ in having the alar septa and the counter laterals enlarged, but in addition to this the cardinal septum is also enlarged, and other septa may similarly suffer enlargement. In primitive forms the counter and counter laterals are undeveloped. Endothecal tissue usually well developed.

Genera at present recognized:

1. *Oligophyllum* Pocta, Devonian
 2. *Cryptophyllum* Carruthers, Dinantian
 3. *Plerophyllum* Hinde, Permian.
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ADDITIONAL SPECIES OF *TACHYLASMA* AND *PLEROPHYLLUM*

Gerth has described five species of Streptelasmoids from the Permian of Timor, all of which he refers to the genus *Plerophyllum*. Two of these must, however, be referred to *Tachylasma*, while two others appear to be true *Plerophyllum* in the emended sense. The fifth is doubtfully referred to that genus. E. Sochkin also has described two new species of *Tachylasma*, and two of *Plerophyllum*, though both of the latter will have to be referred to another genus. Several new species of *Tachylasma* have been obtained from Chinese rocks. We shall first consider the new species of *Tachylasma*, and after that the new species of *Plerophyllum* etc.

Subfamily **TACHYLASMAINAE** GrabauGenus **TACHYLASMA** Grabau***Tachylasma beyrichi*** (Rothpletz)

(Text-Fig. 10 a)

1892. *Zaphrentis Beyrichi* Rothpletz, Palæontographica Vol. XXXIX page 69, Pl. 12, fig. 16, 21, 22, 26-29.
1903. *Zaphrentis Beyrichi* Diener, Palæontologia Indica, Series 15. Vol. 1, part 5, page 43, Pl. 2, fig. 20.
1921. *Plerophyllum Beyrichi* Gerth, Anthozoen der Dyas von Timor, page 88, Pl. 2, fig. 7-8, text-fig. 5.

This is of the usual conical form, a large individual attaining 5 cm. in length and 28 mm in calicinal diameter. The pinnate arrangement is well shown in the septal grooves on the exterior, from which Gerth has determined that it is the alar and the 1st pair of counter secondaries which are accelerated, by being lengthened and strengthened to a moderate degree above the others. The counter septum itself is but slightly different from the others, but the cardinal septum is highly aborted, which is a feature eminently not characteristic of *Plerophyllum* but is found in *Tachylasma*. Several of the other septa are somewhat thickened, but apparently none of these reach the center, or if they do, they do not produce the marked thickening shown in the more specialized species of *Tachylasma*. According to the text-figure of Gerth, (here reproduced as Text-Fig. 10 a) there are 7 secondary septa in the counter quadrants (8 on one side) counting the 1st pair, and five in the cardinal quadrants. Very short tertiary septa are developed in nearly all of the interspaces.

It is quite evident that this species cannot be placed under *Plerophyllum* but that its affinities are with *Tachylasma*. Indeed the only difference between this

form and the simple *Tachylasma cha* or *T. elongata* is the slighter thickening of the alar and first counter secondaries. The species may be considered as transitional from the normal Streptelasmoid to *Tachylasma* and is best regarded as an undeveloped species of the latter.

Tachylasma timorens (Gerth)

(Text-Fig 10 b-d)

1921. *Plerophyllum timorens* Gerth. Die Anthozoen der Dyas von Timor. page 89, Pl. 2, figs. 9-12. Pl. 3, figs 20, text-figs. 6 & 7.

This species too, cannot be left under *Plerophyllum* where it was described by Gerth, but must be placed under *Tachylasma*. In form and size it is similar to the preceding species, but the epitheca is sufficiently thick, so that the septal grooves are not recognizable on the exterior, which appears smooth except for growth-lines. The alar septa, and the first two counter secondaries or counter laterals are thickened, the latter less so than the former, and, as shown in the sections given by Gerth, this thickening is not always uniform. There is, furthermore, unequal acceleration among the septa, some of the other counter secondaries as well as several of the cardinal secondaries being likewise thickened to a moderate amount, there being apparently a good deal of irregularity in this respect. The counter septum is of moderate length and not perceptibly thickened, but the cardinal septum is shortened. This last fact is sufficient to take it out of the genus *Plerophyllum* and place it in *Tachylasma*.

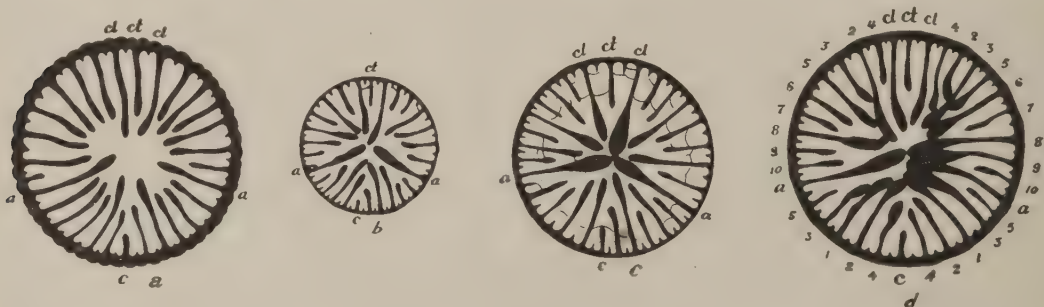


Fig. 10. Sections of *Tachylasma* from the Permian of Timor (after Gerth (*Plerophyllum*) with modified lettering.) a. *Tachylasma beyrichi* (Rothpletz); diagrammatic section showing the arrangement of the septa near the calyx. $\times 2$; b, *Tachylasma timorens* (Gerth), Section of a curved hornshaped corallum 4 cm. long, made $1/5$ th the length from the base, $\times 1\ 1/2$; c *Ibid.* Section of same corallum made $3/5$ th the length from the base, $\times 1\ 1/2$; d *Ibid.* Section near the calyx of another specimen showing the order of development of the septa as determined by Gerth. The septa are renumbered in the counter quadrants, the counter laterals (cl) being considered the first secondary septa. a, a, alar septa c counter septum, cl cl counter laterals; ct. counter septum.

There is, however, another complication in the septal development of this type which, if Gerth has correctly diagnosed it, sets it apart as a type distinct

from other corals of this group. This is the order of appearance of the secondary septa. There are in all 10 secondary septa in the counter quadrants of a large specimen, including the 1st pair, while the cardinal quadrants have 5 secondary septa. According to the determination of Gerth, made by the removal of the epitheca, it appears that the septa of the counter quadrants arise in the regular order with the exception of the 4th (the 3rd according to his method of designation), which appears between the 1st and second as if it were a tertiary one. In like manner the order of appearance of the cardinal secondaries is abnormal, the 3rd appearing between the 1st and the alar, and the 5th between the 3rd and the alar. It remains to be seen whether the method of determination adopted by Gerth is a reliable one. If the order proves to be as indicated, we have here a marked deviation from the normal order of succession unless we consider these abnormal septa enlarged tertiaries. Nevertheless the species is to be related to the Chinese species of *Tachylasma* rather than the Australian *Plerophyllum* unless indeed, this mode of departure of septal derivation may be regarded as of sufficient importance to raise its possessor to a new generic rank.

***Tachylasma rizoides* Sochkine.**

(Text Figs 11 a-e)

1925. *Tachylasma rizoides* Sochkine. Bull. Soc. Natur. Moscou page 85, Pl. I, Fig. 2-5.

Corallum simple, fixed by radiciform extensions from the epitheca, and usually presenting a straight or slightly curved cone. The epitheca is thin, and the septal grooves are well marked, showing the pinnate arrangement. The lines of growth are fine and sometimes augmented by stronger wrinkles.

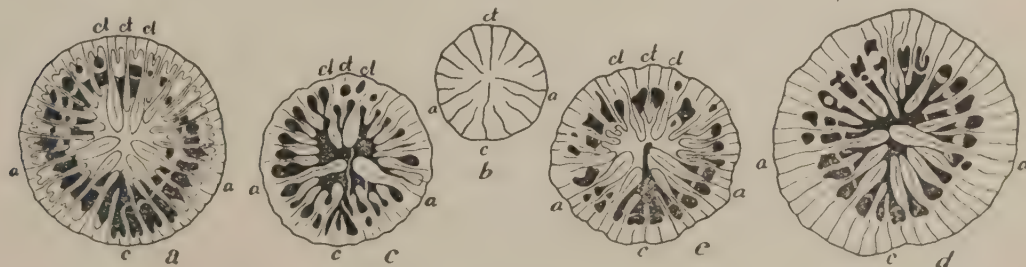


Fig. 11. *Tachylasma rizoides* Sochkine a. section of a normal individual; b. young stage of the same. Permian of Oufa; c.—e. Sections of other individuals from the Permian of Perm, Russia. All enlarged. (After Sochkine); a. a. alar septa c. cardinal septum; cl, cl, counter laterals, ct counter septum.

The section of a young stage (pl. 1, fig. 2 a, our Text-Fig 11 b) shows conditions almost identical with those of *T. aster* Grabau. (Fascicle I, page 41, Fig. 51). The four primary septa are long, nearly reaching the center, and the first pair of counter secondaries is equally long. There are four secondaries in one counter quadrant and 5 in the other, the last of these being short, thus showing an unequal acceleration. In the cardinal quadrants there are two secondaries on the side corresponding to that with 5 in the counter, while on the opposite side there are 3 secondaries in the cardinal quadrants, thus making the total number of secondaries on each side similar, though with the unequal acceleration referred to. In subsequent stages the alar and the two first pair of secondary septa of the counter quadrants become thickened. The counter septum remains behind in development and in some individuals becomes shortened. The cardinal septum is likewise aborted, but one or more of the secondary septa, usually the seconds or the second and the third, also become thickened. A certain amount of thickening also takes place in the other secondary septa of the counter quadrants, but the thickening of the septa in these quadrants seems to be on the whole less than in those of the cardinal quadrants. There is distinct unequal acceleration in the septa of both cardinal and counter quadrants. The second pair of counter secondaries is generally less accelerated than the third, and the 4th less than the 5th and 6th. In the same way the 1st of the secondary septa in the cardinal quadrants is less accelerated than the second, or sometimes, as in Fig. 2 where one of the cardinal quadrants is more accelerated than the other, there are two retarded secondary septa between the thickened septum and the alar. This is, however, an individual variation.

It is to be noted that in the Chinese species of *Tachylasma* the 1st pair of secondaries in the cardinal quadrants is also retarded.

This Russian species then differs from *T. cha* and *T. elongatum* in the additional thickening of septa in both the cardinal and counter quadrants. From *T. aster* of the Chinese rocks, in which such thickening does take place, it differs chiefly in the fact that the counter septum remains aborted while the thickened septa do not unite as markedly into a star-shaped body in the center as is the case in the Chinese species; furthermore, the cardinal septum is aborted, whereas in *T. aster* it remains long and slender. A few dissepiments are developed as they are in *T. aster*.

The dimensions of the largest specimen recorded are: Length more than 60 mm. Diameter 16 mm. Number of longer septa 30, (4 primary and 26 secondary) with an equal number of tertiary ones. Depth of the calyx 15 mm. In this specimen

the cardinal septum and the fossula formed by its abortion lie on one side of the corallum. In other specimens it lies on the concave as often as on the convex side of the corallum. The distribution of the 30 septa is as follows: 4 primary, 4 or 5 secondary in each cardinal quadrant, and 9 or 8 secondaries in the corresponding counter quadrants (see Text-Fig. 11 a). It is thus seen that the counter quadrants contain almost twice as many secondary septa as the cardinal, indicating their strong acceleration.

HORIZON AND LOCALITY: This species has been recorded from a number of localities in the Artinskiar of the western Ural region, 27 specimens in all having been obtained by Sochkine.

***Tachylasma latum* Sochkine.**

1925. *Tachylasma latum* Sochkine, Bull. Soc. Natur. Moscou page 86.

This species occurs in the form of a large massive cone reaching a length of 50 mm, with a diameter of 24 mm or over, and a depth of calyx of 28 mm. Epitheca thick with concentric wrinkles and growth-lines with the septal grooves very pronounced, showing the pinnate arrangement of the septa as in the typical streptelasmoid form. Radiciform extensions apparently absent. The calyx is profound, with 30 long septa at a diameter of 24 mm, with an equal number of tertiary ones. The disposition and character of the septa is essentially like that of *T. rizoides* they being similarly thickened at their ends. Where the diameter is 14 mm, the number of septa is 22. Tabulae are absent but the lower part is completely filled with stereoplasm.

This form differs from *T. rizoides* in its much larger and more massive conical form, its deep calyx, smaller number of septa at corresponding diameters, and the absence of radiciform extensions.

HORIZON AND LOCALITY: In the Artinskian of Lytva River, government of Perm.

SPECIES DESCRIBED FROM YUNNAN

***Tachylasma* sp.**

1927: *Plerophyllum* cf. *timorensis* Cowper-Read, Palæozoic and Mesozoic Fossils from Yunnan p. 109 Pl. XI, figs. 5-8.

Cowper-Reed, has described and figured a small coral from Yunnan which he refers to *Plerophyllum* conf. *timorensis* Gerth. This is almost entirely represented

by molds of the interior and its relationship is difficult to ascertain. The commonest type "consists of small corals of a broadly conical form, like Loczy's figures 25 and 26, and have an average calicinal diameter of about 15-20 mm. Most of them are crushed or imperfect, but in two transverse sections near the base, we can see the internal swollen ends of the 4 or 5 principal septa as in *Pl. timorensis* Gerth and its allied species. There are about 32 primary septa and as many very short and thin secondary [tertiary] septa, in a specimen of the average size. The pinnate arrangement is very marked and the strong development of the lateral and chief septum and shorter counter septum are specially noticeable. The other internal characters are not clear. A fairly regular median longitudinal line of small pits lies along the outer wall of each interseptal loculus and in the casts they are represented by small tubercles and may correspond with similar structures figured by Etheridge jun. in *Zaphrentis* (*Plerophyllum*?) *gregoriana* De Koninck from the Permo-Carboniferous of New South Wales and in the Silurian *Cyathophyllum* (*Paleocyathus*) *australe* Foerste, also from New South Wales". (*Loc. cit.* p. 110).

Plerophyllum timorensis as shown above, is really a *Tachylasma*, and the internal mold *i. e.* the fillings of the interseptal loculi, suggests that this Ta-Li-Shao coral is a representative of that genus; for the cardinal septum is certainly aborted, while the alar and the counter laterals are strongly developed, the shortening of the cardinal septum producing a fairly well-marked fossula. Whether, however, this coral is to be referred to Gerth's species, or to another species of *Tachylasma*, cannot be determined.

Cowper-Reed describes and figures another small coral from the same horizon and locality, that is, the soft yellowish mud-stone of Ta-li-Shao, which he refers doubtfully to *Tachylasma cha* Grabau (page 110, pl. 77, fig. 9)

"The secondary [tertiary] septa are quite rudimentary or even absent. The primary [primary and secondary] septa which number 20-25 are thick and all have the characteristic swelling of the inner ends figured by Grabau. The one isolated specimen here figured shows the septa preserved near the calyx on a transverse fracture. The diameter of the coral is about 10 mm."

This small coral has certainly the form and general characters of *Tachylasma cha*, though because of the imperfect state of preservation, I quite agree with Cowper-Reed, in not making the identification a positive one.

NEW SPECIES OF *TACHYLASMA* FROM CENTRAL CHINA

(With further examples of previously described species)

Tachylasma lopingense Grabau (sp. nov.)

Plate I, Figs. 7a-d, 8-10.

A number of more or less indifferently preserved specimens of this species have been found in the Loping coal series, ranging up to 20 mm in length and

approximately 10 mm in diameter. The most perfectly preserved among these is a small individual selected as the holotype with a length of about 12 mm to the bottom of the calyx, the rim of which has been broken away (Pl. I Fig. 7a-d). The maximum diameter at the level of the calyx floor is 7.9 mm. It is slightly curved, with the alar septa on the sides, but the counter septum on the concave side and the cardinal on the convex, or side of greatest curvature. The septal grooves are well marked and they indicate 7 septa for the cardinal quadrants and 9 for the counter. As seen in the calyx however, there are three secondary septa in each cardinal quadrant and 4 tertiary, while there are 4 secondaries in the counter and five tertiaries.

The cardinal septum is long, reaching practically to the center, but it is narrow and tapers to an edge, it is also slightly flexuous. The alar septa nearly reach the center, but do not quite touch each other. They are strongly thickened in the usual club-shaped manner, their maximum thickness being 1 mm. They are furthermore exert, projecting considerably above the septa of the counter quadrant but less above the cardinal quadrant. The median line of the septum is marked in the right-hand one, and in the center has a slightly zigzag outline. This is merely a depression, there being apparently no median plate; it marks the line of junction of the two layers of stereoplasm deposited on the outside. It thus appears that the original alar septum is out-grown by the deposits of stereoplasm which meet above the original median plate *i. e.* the primitive septum, and continue the septum as a double layer of stereoplasm. A transverse section taken just at the right point would give the appearance of two parallel septa joined on the inside, or in certain cases even as ending freely and separated by a very narrow interspace. This is the condition shown in the section of *Oligophyllum permirum* described on pp. 51 and 52 of this memoir.

The counter septum reaches about $\frac{2}{3}$ the way to the center, but on the whole is but slightly thickened, the maximum near the center being 0.5 mm. The increase in thickness is a very regular one inward. It too is slightly exert and shows faintly the median line.

The first pair of counter laterals *i. e.*, the first secondaries of the counter quadrants are very prominent and moderately exert extending to the center where they touch the alar. Like these they are thickened, the maximum of the left hand one being one mm, while the right hand is slightly less. Both show the median line of contact of the lamellae, which is slightly depressed and of a somewhat undulating outline.

The second secondary septum of the counter quadrants is shorter and thinner than the 3rd. The latter is very slightly thickened but does not reach the dimensions of the 1st septum which it touches at its inner end. It also shows the median line. The 4th septum is slightly thinner and joins the 3rd at its inner extremity.

In the cardinal quadrants, the 1st secondary septum is short, reaching only about half-way to the center and ending in a sharp free edge. The second is the longest and strongest, reaching nearly to the center where it touches the alar. The 3rd is slightly shorter and joins the 2nd. There is thus a pinnate arrangement seen in these secondary septa of the cardinal quadrants.

Tertiary septa appear in all the interspaces including those of the alar and cardinal pseudo-fossulae which indicates that the coral has reached its full complement of secondary septa and is therefore adult. All the tertiary septa are of equal length, projecting only very slightly beyond the calicinal wall, which at the level of the calyx floor is thickened by stereoplasm to about 0.8 mm.

A comparison of this specimen with the holotype of *Tachylasma cha* (Fascicle I page 35, Pl. I, fig. 2a & 2b) shows several marked distinctive features. In the first place, this is a much more slender form, the angle of divergence of the sides being about 25°, whereas that of the holotype of *Tachylasma cha* is 55°. In the latter the septa do not reach the center, the 4 thickened septa having a length of only about 3/4 of the radius, whereas in the present form they meet in the center. Again in the holotype of *T. cha*, the number of secondary septa in the counter quadrants, including the 1st pair of counter laterals, is 8, while in the cardinal quadrants the number of secondary septa is 4, whereas in the present form, the total number of secondary septa in the counter quadrants is 4 and that of the cardinal 3. Thus not only is the total number of secondary septa in *T. cha* much greater, but the degree of acceleration of the counter quadrants is also more pronounced, it having twice the number of secondary septa found in the cardinal quadrants, the proportion being as 2 to 1, whereas in the present form the number is only one in excess, the proportion being as 4 to 3. This difference in the total number of septa is, of course, commensurate with the greater rate of divergence in *T. cha*, but since in both forms tertiary septa are well-developed in all the interspaces, including the alar and cardinal pseudo-fossulae, we must conclude that we are dealing in each case with adults. Hence it would seem legitimate to refer the present form to a distinct species. It might be further added that the cardinal septum in the present form is more strongly developed reaching the center, whereas in *T. cha* it is very short, forming a fossula.

PARATYPES: While there is a certain amount of variation among the corals of this species, they all agree in their relatively slender form and moderate amount of divergence. Sometimes the exterior seems to be very smooth, in other cases, it is strongly wrinkled.

A section of an individual about 7 mm below the calyx floor, at a point where the diameter is 7 mm, shows the alar and 2 counter laterals only moderately thickened, though in each case they are more marked than the other septa. The cardinal septum is slender and long, and the same thing is true of the counter septum, which is only slightly less pronounced than the counter laterals. None of the septa quite reach the center, though the four thickened ones and the cardinal come within a very short distance of it. In this individual there are 4 additional septa in all in the counter quadrants, all being much shorter and thinner than the 1st pair, the second pair being shorter than the others. In the cardinal quadrants there are three secondary septa, progressively increasing in length from the 1st to the 3rd, the latter in the left hand quadrant (right, in the figure, as that is seen from below) is nearly as strong, though not as long as the alar, but in this quadrant there are only two secondaries. Tertiary septa are present in all the interspaces, though in this case, where the total number of septa of all 3 cycles amounts theoretically to 40, only 38 are present because of the suppression of one secondary and one tertiary in one of the cardinal quadrants. The usual number of septa, as indicated by the septal grooves is 36, which is distributed as follows: 4 primary, 4 + 4 counter secondaries 3 + 3 cardinal secondaries and 18 tertiaries. It may, however, happen that the tertiary in the alar pseudo-fossula develops into a secondary while new tertiaries appear on either side, thus making the total number of septa 40, which is the theoretical number of the specimen just referred to, with 5 secondaries in the counter quadrants. Of course this development may go on until the total number of 8 secondaries and 9 tertiaries has appeared in each counter quadrant, which is the number in the holotype of *Tachylasma cha*. Moreover, if we consider the short septum on either side of the cardinal septum in *T. cha* an immature secondary, we have 5 secondaries in in each quadrant, but only three tertiaries, since no tertiary has developed between the 3rd and the 4th (see fig. 50 page 36 Fascicle I). This fact alone would suggest that the short septum on either side of the cardinal is an immature secondary one, rather than a tertiary, for a tertiary should develop between the 3rd and the 4th before it develops between the 4th and the cardinal, *i. e.*, in the cardinal pseudo-fossula. With 5 secondaries in the cardinal quadrants there should then be six tertiaries if all the interspaces are occupied. This would give for the mature *T. cha* 60 septa in all, namely 4 primary 8 + 8 counter secondaries, 5 + 5 cardinal secondaries, and 30 tertiaries.

As stated, it is perfectly conceivable that the present form may eventually develop that number of septa, but in that case it would have to grow to corresponding diameter, which at the indicated rate of tapering would make a coral about twice the length of the holotype plus the added length of the calyx depth. Thus it appears that this must be considered a more retarded type, which is correlated with the slower divergence. It may either be ancestral to *T. cha* or, what is more likely, present a case of parallel development.

HORIZON AND LOCALITY: In the Loping coal series of Mid-Permian age, Loping Kiangsi Province. Collected C. C. Liu. Several specimens.

***Tachylasma magnum* Grabau (sp. nov.)**

Pl. I Fig. 11 a-g, Fig. 12 a-b

This species is based upon a single incomplete specimen about 30 mm in length, and about 21 mm in maximum diameter, although when the calyx rim was complete, it must have been somewhat larger. Another fragment of a large individual is also referred to this species. The first mentioned specimen so far as preserved is shown in Fig. 11a, the drawing having been made before the specimen was sectioned. A series of sections was then made, and these alone are preserved at the present time. As seen from the figure, the corallum is gently curved; as in the two other species of *Tachylasma*, it is the counter septum which occupies the side of greatest curvature, *i. e.*, in the position where the cardinal septum is usually found. The epitheca is mostly decollated, but the growth-wrinkles are still shown. The septal grooves are well marked, and from them it can be seen that the tertiary septa appear at a very early stage. We shall first describe the adult characters and then take the sections serially from the earliest upwards.

Section through the Calyx of the Holotype

Pl. I, Fig. 11g.

This has a maximum diameter of about 20.5 mm and the longest septa at this stage reach a little more than half way to the center. The alar, and counter laterals are most prominent, and apparently were somewhat exert, at the same time projecting slightly further than the others into the calyx. They are but moderately thickened at this stage, the maximum being not over 0.6 mm, but as such they are thicker than any of the other septa. The cardinal septum is the shortest, having a length of about 1.8

mm, the counter is somewhat longer, but less than half the length of the 1st pair of counter laterals or secondaries. There are seven secondary septa in each cardinal quadrant, the first three slightly shorter than the next three, while the 7th is shorter than the cardinal but longer than the tertiary septa, which occupy the first six interspaces, not being developed in the 7th or 8th. In the counter quadrants there appear to be 10 additional secondary septa on the left and 11 on the right side which is slightly more accelerated, thus there are 11 + 12 secondary septa in all in the counter quadrants, an excess in each of at least 5 over each cardinal quadrant. The first 3 or 4 of the additional counter secondaries are considerably shorter than the others which follow. Tertiary septa appear in all the interspaces. There are no dissepiments or endothecal structures, and the epithecal wall is thin, not exceeding in thickness the septa.

Section below the Calyx Floor.

Pl. I, fig. 11 f

This is about 7 mm below the preceding one and is shown in Fig. 11f. The diameter here is about the same, while the principal septa reach to within a short distance of the center. The most prominent septa now are the counter laterals which are thickened inward in a club-shaped manner, and terminate in a rounded inner edge. The maximum diameter is 1.5 mm. The counter septum between them is thin and longer than in the calyx, but does not exceed $3/4$ the length of the counter laterals. The alar septa are longer, though not so strongly thickened. The maximum length is 9 mm, where the diameter in the same direction is 20 mm. In the left hand counter quadrant (right as seen in the figure which is reversed, being viewed from below,) there are 10 additional secondary septa, making 11 in all. The first 4 of the additional laterals, that is septa 2-5, are shorter than the 1st and terminate in slender points, but the 6th is about as long as the 1st (about 7.5 mm) and is also somewhat thickened, but only to the extent of that shown by the counter laterals as seen in the calicinal section. The remaining septa of this quadrant show a regular decrease in length, the last being shorter than all the others, though much longer than the tertiaries which occupy all the interspaces except the the last two, there being thus 10 in all instead of 12.

On the right side, (left in the figure,) the coral is imperfect, but it is possible to determine that there are 3 shorter septa immediately following the 1st or counter lateral. The 5th on this side is as long as the 6th on the opposite side and of about the same thickness. The 6th and 9th are somewhat shorter, but the 7th, 8th and 10th are long, after which there are 2 more progressively decreasing septa, making 12 in all on the right side. Moreover, there are tertiary septa between all the

secondaries, and in the alar pseudo-fossula as well, making 13 in all on this side. The alar septum which follows is again very long and thickened to a maximum of nearly 1 mm, while the inner end is rounded.

The cardinal quadrant on the right side (left in the figure) is complete. The first 3 secondary septa taper to points and are of equal lengths. The next two are more thickened and of about twice the length of the first 3. The next *i. e.* the 6th is somewhat shorter, but still longer and more thickened than the first 3. The cardinal septum is short. Thus the number of secondary septa in this quadrant is just one half that of the secondaries in the counter quadrant, essentially as in *Tachylasma cha*, but the relative lengths of the septa differ and the thickness of the alars is less than that of the counter laterals, whereas it is the reverse in *T. cha*. The most striking feature is the strong development of the 4th and 5th secondaries, *i. e.* the last two but 1 of the secondaries. Tertiary septa are present in all the interspaces, and seemingly in the cardinal pseudo-fossulae as well, though these are in reality secondary septa as shown by their greater length in the section through the calyx. With this recognition of their characters as secondaries rather than tertiaries, the total number of secondaries is 7, with the tertiary septa in 6 of the interspaces. Though not quite perfect the other cardinal quadrant *i. e.* the left (right in the figures), shows essentially the same development, except that the 4th is somewhat longer and thicker than its fellow in the opposite quadrant, while the 5th is slightly shorter.

No dissepiments or other endothecal tissues are shown, and the epithelial wall and outer ends of the septa are but slightly thickened.

Earlier Sections.

SECTION B. Section at the point marked b in Fig. 11a (Pl. I fig. 11b). This is the lowest section obtained through the corallum and its features are shown in Fig. 11 b. The dorso-ventral diameter at this stage is 11.5 mm and the 4 prominent septa are in the order of their thickness, the two counter laterals and the two alars. The septa reach nearly to the center and are moreover united there. The length of the counter laterals is 5.2 mm, which is but slightly less than half the diameter of the corallum. The maximum thickness here is about 0.9 mm and the inner ends are rounded and joined together by extensions of the other septa, which also join them to the alar. The counter septum is only about half the length of the counter laterals, slender and slightly flexuous. The most marked feature is the junction of the secondary septa in the counter as well as the cardinal quadrants. This junction is nearly complete, the ends of the secondary septa in the counter quadrants

merging with the stereoplastic thickening of the first. The third joins the second, the 4th is free, the 6th joins the 5th, but the 7th and 8th appear to be free but shorter. Most of the septa of the cardinal quadrants are united into one or more groups, the earlier touching the alar septa. What appear to be spur-like prolongations from the alar septa join them to the counter laterals.

SECTION C. A slightly higher section (c) (Pl. I Fig 11c) with a dorso-ventral diameter of 11.7 mm shows most of the septa free, except the last 3 which are still more or less conjoined. The total number of secondary septa in the counter quadrants including the counter laterals is 9, and tertiary septa are developed in most of the interspaces. In some cases these tertiary septa bend over and touch the adjoining secondary away from the counter. The cardinal septum reaches about half way to the center and like most of the other septa, is slightly flexuous, but somewhat thicker than they. There are five long secondary septa in the cardinal quadrants, all tapering to a fine edge; the first 3 are shorter than the 4th and 5th, the 4th on the left side extending almost to the center and touching the inner ends of the corresponding alar. Tertiary septa occur in all the interspaces, including the cardinal pseudo-fossula, though these may be undeveloped secondaries. Both in this and the preceding section a few dissepiments appear, but they are irregularly developed and not numerous.

SECTION D. (Pl. I, Fig. 11d) This is about 5 mm higher than the preceding one and has a dorso-ventral diameter of 13.7 mm. The septa of the counter quadrants appear partly united and partly free, the best developed being the 5th on the right and the 6th on the left, both of these touching the stereoplastic thickening of the counter laterals. There are 11 septa in all in the right-hand, and only 9 in the left-hand counter quadrants. The cardinal pseudo-fossulae are bounded by the delicate extension of the septal ends which touch the alars, while some of the others also unite and extend to the alars. There are now six in each cardinal quadrant and the cardinal septum extends half way to the center. The 4th in each quadrant is still the strongest septum. A few dissepiments are present.

SECTION E. (Pl. I, Fig. 11e). This is about 5 mm higher and has a diameter of approximately 15.5 mm. Little change has taken place except that an additional septum is formed in the counter quadrants making 10 in all in the left-hand, and 12 in the right-hand quadrants. The cardinal quadrants have still 6 secondary septa in each, the 6th continuing as a delicate bounding line of the fossula which is now more pronounced because of the shortened cardinal septum, which extends only about $1/4$ the distance to the center. An additional short septum has arisen on either side of the cardinal septum, appearing like a tertiary. Dissepiments are rather more numerous.

There is much filling of the inner cavities by crystalline lime, especially in the lower part, which gives the appearance of stereoplasm but is purely inorganic. Nevertheless it contrasts very strongly with the brown matrix which fills the upper part and in which the coral is embedded.

The later stage below the calyx bottom has already been described and there it is shown that there are 12 secondary septa in the right-hand counter quadrant and 11 in the left-hand, while each of the cardinal quadrants still retains 6. All the septa are now free and the cardinal is very short. There is, however, a short septum on either side of it, which in the final section through the calyx is seen to have grown into an additional short secondary one. Tertiary septa are present in all the other spaces, but dissepiments have now disappeared.

The large size and large number of septa, especially in the counter quadrants, distinguish this species from all the others so far described.

HORIZON AND LOCALITY: In the Cherty Limestone of the Lower Wushan Limestone Series (Permian) at the Shintan Rapids of the Yangtze Gorges, Hupeh Province. Y. T. Chao Collector. Cat. G. S. C. 1555.

Paratype

What appears to be a large individual of the same species has been obtained from approximately the same formation, but a somewhat different locality. It is illustrated in Pl. I, Fig. 12 a, b.

The Corallum reaches a diameter approaching 40 mm, and is of unknown length, only a fragment embedded in rock having so far been obtained. A section approximately 35 mm below the calyx has a diameter of about 27 mm, and shows the following characteristics. The alar septa are the most prominent, almost reaching the center, and have thickened club-shaped ends about 1.5 mm thick. The first 3 septa in the cardinal quadrants reach only about half-way to the center. The 4th is long, as long as the alar, and like them thickened by secondary stereoplasm, though not quite to the same extent, the maximum being less than 1 mm. The 5th, 6th and 7th increase regularly, all forming a sort of faint arching over the cardinal, which extends about 1/4 or less of the distance to the center. The counter septum is long and thin extending about 2/3 the distance to the center and ending in a taper. The 1st pair of secondaries, *i. e.* the counter laterals, are strong, approaching to within a short distance of the center, and being thickened to a trifle over 1 mm. There are 11 secondary septa in each counter quadrant including the 1st, the 4th in each case being almost equal in length, though not quite in thickness, to the 1st, the same being true of several others of the secondary septa. There is, however, a certain amount of irregularity. Dissepiments are sparingly developed.

At the ascertained rate of tapering, the total length would be something over 10 cm but the earlier stages probably taper more rapidly. To reach the maximum diameter of the previously described specimen at the ascertained rate of tapering would cover a length of 17 mm and make a total of about 50 mm, with the addition of the smaller specimen. Owing to the fact that the number of septa is in excess in the right-hand counter quadrant, and is 1 more than in the corresponding quadrant of the larger specimen, we cannot consider the two specimens as representing the same individual, though there cannot be much doubt that they represent the same species.

HORIZON AND LOCALITY: This specimen has been obtained from the Permian Chert limestone of the Lower Wushan Limestone, in the float lying about 200 m above the base of the Chert Limestone, at Kien-yang-Ping, Hsing-Shan-Hsien, Hupeh. Y. T. Chao Collector. Cat. 1556.

***Tachylasma elongatum* Grabau**

Pl. I, Fig. 13 a, b.

(Fascicle I, p. 37, Pl. I, figs. 13 a-c).

Corallum sub-cylindrical, only a fragment preserved, having a length of 15 mm after 2 sections have been cut from it. There is almost no tapering in that interval. The dorso-ventral diameter of the section is about 13.5 mm which is slightly more than the transverse diameter (13 mm), owing to a slight obliquity of the section. The alar septa are only slightly more thickened than many of the secondaries, and slightly less than the counter laterals, which reach a maximum of about 0.8 mm, and which, like the alar, extend to within a short distance of the center. The counter septum is somewhat shorter, and is slender and flanked on either side by two well developed septa. There are 9 secondary septa in 1 of the counter quadrants, and 8 in the other; the 2nd and 3rd are shorter than the 4th and 5th, which are almost as prominent as the 1st. Well developed tertiary septa, nearly $\frac{1}{3}$ as long as the longest secondaries, are found in all the interspaces except the alar pseudo-fossulae. There are 3 well-developed secondary septa in each cardinal quadrant, reaching $\frac{2}{3}$ or more the distance to the center and of equal length; a 4th flanking the cardinal septum, has the length of a tertiary septum. Tertiary septa occur in the other interspaces. The cardinal septum is a little shorter than half the radius. Dissepiments rare and irregular.

This species differs from the others in the strong acceleration of the counter quadrants, in which respect it closely resembles *Tachylasma cha*. Indeed the chief differences between this species and the genotype are: the moderate thickening of the

four exert septa, which scarcely reaches half that of *T. cha* in proportion, the relatively greater length of the tertiary septa, and the sub-cylindrical form of the corallum as a whole. In this last respect it corresponds to the genotype of *T. elongatum* Grabau, but that corallum has only 7 secondary septa is the right-hand counter quadrant and 8 in the left, while there are four well developed secondary septa in the cardinal quadrant of which the 1st is the shortest. Both cardinal and counter septa are shorter in the holotype than in the present form and the alar are slightly more thickened than the counter laterals. Finally the tertiary septa in the holotype are much shorter. Since however the section shown in the illustration of the holotype is essentially a calicinal one, or only a short distance below the calyx, the shortness of the tertiary septa and possibly that of the counter and cardinal may be accounted for. The maximum diameter of the holotype is 15 mm and its rate of tapering is a gentle one.

On the whole then, it would appear that the present species presents a slight modification of the conditions shown in the holotype, which comes from equivalent strata in an adjoining province and until more material is obtained to show more important differences we shall refer this specimen to the already described species.

HORIZON AND LOCALITY: In the Permian Chert Limestone of Pai-tze-kou, Soo - Sung - Hsien, Anhwei Province. Collected by C. C. Wang. Associated with *Neoschwagerina*? Cat. G. S. Ch. 1557.

The holotype was referred to the Lower Carboniferous limestone with a query (Fascicle I page 35), but it has since been ascertained that it came from deposits of Mid-Permian age, in association with *Productus graciosus* etc., at Fengcheng in Kiangsi. From the same horizon and locality comes the holotype of *Lophophyllum* (*Sinophyllum*) *pendulum* Gr.

***Tachylasma emaceratum* Grabau (sp. nov.)**

Pl. VI, Figs. 13 a-d.

A series of sections in a black limestone show characteristics which suggest that they might belong to the genus *Tachylasma* although there has been no marked thickening of any of the septa. Unfortunately the sections obtained are very oblique and hence it is not possible to determine all of the characteristics. A weathered end of the corallum (Pl. VI, Fig. 13a) which may be near the terminal portion, has a diameter of about 17.5 mm, and shows a relatively short cardinal septum (c) extending about one fourth the distance to the center, and flanked by 5 secondary septa, all of which are well developed, and most of which reach the center, where they unite

in a greater or less degree. The alar septa (a) are slightly stronger than the others and also extend to the center, without, however, marked thickening. Here they are joined by the longer septa of the cardinal quadrant. The counter quadrants are accelerated, but apparently unequally so. The total number of septa is 19 including the counter, but instead of 9 on each side there appear to be 10 on one and 8 on the other *i. e.* the right side. The counter reaches part-way to the center and is flanked by the rather stronger counter laterals which extend beyond it and tend to surround it on the inner side. The other septa are partly free and partly grouped.

SECTION 2. In a section at least 10 mm lower (Pl. VI, fig. 13b) the diameter is 12.3 mm, this being the minimum and probably the true diameter, the maximum being much greater due to the obliquity of the section. In this case the *Tachylasma* appearance is more strongly marked, in that the alars and the counter laterals appear to meet to form the characteristic symbol *Ch'a* (X). The counter extends about two thirds the distance to the center and tapers to a sharp edge. It is entirely enclosed by the counter laterals. Owing to the mode of preservation, the greater length is preserved in porous stereoplasm as are most of the septa, and thus appears white. The inner continuation not thus preserved is very faint. Thus the septum appears to extend only half way to the center. The counter laterals are slightly stronger and curve towards each other in the center where they meet and entirely enclose the space occupied by the counter septum. The next 3 of the counter secondaries join with the 1st, forming a group, and the three succeeding also form a group which join the central complex. The 3rd of these, that is the 7th in all, joins the preceding one before the center. In the right-hand quadrant there is an 8th which joins the 7th about half-way to the center. This is also seen in the left-hand quadrant, where, however, it is very faint. The alar septa are as strong as the first pair of counter laterals, that is, slightly stronger than the other secondaries. There are 5 secondaries in each cardinal quadrant, the first 3 uniting into a group and approaching, but not actually meeting the alar near the center. The 4th and 5th are somewhat shorter. The cardinal septum is not distinguishable in this section, but its location is shown by the broad fossula-like gap. Tertiary septa faint and short.

Dissepiments are moderately developed, especially near the outer margin.

SECTION 3. A section about 4 mm lower (Pl. VI, fig. 13c) has a tranverse diameter of 9.1 mm which is approximately the normal diameter at this stage, the section being also oblique. The alar and counter laterals still meet in the *Ch'a*-like manner, the counter septum between them now being short and reaching half way to the

center. The other secondaries of the counter quadrants join the 1st in a group except the 7th, which is free and the 8th, which is short and joins the 7th. These are only shown on the right-hand side (left as it appears in the section which is reversed). On the left-hand side the section is imperfect but even so the number of the septa seems to be much less. In the cardinal quadrants there are 5 secondary septa in each, mostly grouped, though some of them are free. The cardinal septum itself is somewhat shorter than the others. In this section the alar and the two counter laterals appear the strongest, but while the latter have their ends thickened and united, the ends of the alar septa are tapering.

Dissepiments are fairly common and there is an additional filling of porous stereoplasm in many but not all the interspaces.

SECTION 4. (Pl. VI, Fig. 13 d) This is several mm below the preceding one where the dorso-ventral diameter is 7.4 mm, which is the shortest, and probably correct measurement. The conditions are much as in the preceding section. The counter laterals are thickest, and they and the alar are joined medially. The counter septum extends less than half the length to the center. The second secondary of the counter quadrant joins the 1st, as do also the 4th & 5th. The 3rd joins the 2nd, the 6th joins the 5th, and the 7th the 6th. The 8th is not yet developed. These are all shown in the right-hand quadrant. The right cardinal quadrant has five secondary septa. The two left-hand quadrants are not well preserved. Short tertiary septa appear to be present in all the interspaces as in the other sections. Dissepiments fairly well developed.

No earlier sections were obtained.

HORIZON AND LOCALITY: In the Permian Chert limestone of Yang-Kong-Chow, Kuei-Chih-Hsien, Anhwei. Associated with *Fusulina*. Collected by Messrs. Yih & Li, Locality 712. Geol. Surv. China Coll. Cat. 1558.

Subfamily **PLEROPHYLLINAE** Grabau

Genus **PLEROPHYLLUM** Hinde
(Emend. Gerth)

Plerophyllum radiceiforme Gerth

(Text-Fig 5c, p. 28)

1921. *Plerophyllum radiceiforme* Gerth. Anthozoen der Dyas von Timor, page 92, Pl. II, figs. 15-18, text. fig. 8.

This appears to be a true *Plerophyllum*, having well-developed cardinal, alars, and 2 counter laterals. The counter septum itself is moderately developed between

these two secondary septa. The number of secondary septa in the counter quadrants is 6, and in the cardinal 4, making a total of 24 in all. In the type specimen illustrated by Gerth, which is remarkable for its slender tap-root form, the apical part of the same specimen, about 4 mm in diameter (Gerth pl. 2. fig. 18), shows the 5 strong septa of the normal *Plerophyllum*, with a moderately developed counter septum, and three additional secondary septa in the counter quadrants. Thus there are 4 secondaries in each of these quadrants while the cardinal quadrants have three in one and two in the other. As usual in this genus, the development of the several secondary septa is not strictly successive but rather such as to produce something of an alternation of stronger and weaker septa. Tertiary septa are faint or absent, though indicated to some extent in one of Gerth's sections. Tabule are rather numerous, rising towards the center, with a further depression in the middle.

Gerth figures a schematic cross-section from near the apex of a small corallum, which shows the five strong septa somewhat unequally developed, the alar being the strongest, the 1st pair of counter secondaries coming next, and the cardinal, though equally long, being the thinnest (Gerth page 92, fig. 8). There are in all 7 secondary septa in the counter quadrants, including the 1st pair, and 5 in the cardinal quadrants, making with the 4 primary a total of 28. The diameter at this stage is about 6 mm. According to this illustration the septa of the counter quadrants are uniform or decrease somewhat from the earlier to the later, while those of the cardinal quadrants increase regularly from the 1st to the 4th, and the 5th is small.

In the type specimen of this species the septal grooves are scarcely shown because of the strong epitheca. The largest specimen recorded by Gerth is 40 mm long with a calicinal diameter of 10 mm, and a calicinal depth nearly equal to its diameter.

***Plerophyllum weberi* Gerth.**

(Pl. II Figs. 1, 2.)

1921. *Plerophyllum weberi* Gerth. Anthozoen der Dvas von Timor; page 93. Pl. II. fig. 19. Pl. III. Fig. 21.

This is a highly accelerated species of *Plerophyllum*, showing in its youthful stages characters essentially like those of the preceding species, although in form it is more cylindrical with radiciform knobs or extensions of the epitheca. It reaches a considerable length, a fragment 30 mm long having a diameter of 12 mm. The calyx also is deep. In the young stage the counter septum is short, while the 1st pair of counter secondaries is long, as are also the alar septa, and the cardinal septum. Very early, however, the counter septum increases in length, so that the coral presents 6 strong

septa which continue into the adult. In the adult calyx figured by Gerth, there are 6 secondary septa (5 only on one side) in the counter quadrants, and 4 in each cardinal. This gives a total of 24, but Gerth also reports others with a total of 26 primary and secondary septa. Tertiary septa appear early in most of the interspaces, this too being an evidence of acceleration over the other species of this genus.

A similar septal arrangement is indicated in de Koninck's figure of *Pentaphyllum armatum* de Kon. (pl. XXXIX fig. 8a), where in addition to the cardinal, alar, and two counter secondaries, the counter septum is equally enlarged, producing six strong septa. There is, however, one marked difference between the Tournaisian and Permian species, and that is the fact that there are, according to de Koninck, six secondary septa in the counter quadrant (quart de circle opposé) and seven in each cardinal quadrant (quart de circle principal) or 30 in all including the 4 primaries. There is a similar number of tertiaries. This then seems to be a case of acceleration in the cardinal quadrants, a fact of such significance, that, if proven, it would require the placing of *Pentaphyllum armatum* de Kon. into a separate family, the septal similarity being the result of independent development, and instead of indicating relationship, being merely a case of parallelism, though in different geological horizons.

***Plerophyllum? cyathophylloides* Gerth.**

1921. *Plerophyllum cyathophylloides* Gerth. Anthozoen der Dyas von Timor, page 90. Pl. II. fig 13-14.

This is a remarkable form which may have to be placed in a distinct genus. It shows repeated rejuvenescence with abrupt contractions, which leave the septated margins of the older calices freely exposed, and give the appearance of a series of invaginated cups. This, together with the numerous septa and many dissepiments, suggest a cyathophylloid coral, but the septal arrangement is strictly bilateral. In a corallum 15 mm in diameter, there are 24 long septa *i. e.* 4 primary and 20 secondaries, and an equal number of tertiaries. In a larger specimen, 22 mm in diameter, there are 34 primary and secondary septa. The counter septum is strong and reaches nearly to the center. It is flanked by two long secondary septa; the alar also reaches nearly to the center, while the cardinal septum is somewhat shorter. This, as we have before noted, is an anomalous arrangement for *Plerophyllum* and is more suggestive of *Tachylasma*, but the septa are not normally thickened and the strong development of the tertiary septa as well as the peculiarity of growth, forbids reference to that genus. The simplest disposition of this type would be its reference to a distinct genus. The tertiary septa are sometimes so long that they may resemble the secondaries. Some of the longer septa

are, however, slightly thickened at their inner ends where they may meet. We shall not attempt to determine the relationship of this form since the characters of the young are not available.

Subfamily **SOCHKINEOPHYLLINAE** Grabau (nov.)

Small simple corals, in which the alar and counter septa are generally enlarged, and often a number of the secondaries in both quadrants as well, but not the first pair of counter laterals. The counter septum may extend to the center, but is sometimes slightly thickened as in *Lophophyllum*, which these forms often resemble, especially in the earlier stages. In primitive forms there may be no marked thickening, but the counter septum is extended. Tertiary septa indicated or variously developed; and irregular tabulae, more or less arching in the center, occur. Known range: Permian.

Genus **SOCHKINEOPHYLLUM** Grabau (gen. nov.)

Conical or conico-cylindrical, simple corals, of the general habitat of the STREPTELASMAIDÆ, generally reaching a large size for the members of the family. Counter septum prominent reaching the center, where it is often thickened after the manner of *Lophophyllum* without, however, having the center separated as a palicol-umella. Counter quadrants accelerated over the cardinal, the secondary septa reaching approximately uniform size in the more primitive forms, where they taper and do not reach the center. In the more specialized forms one or more pair may be strongly developed and thickened like the counter septum, but not quite extending to the center. Alar septa thickened in specialized forms, as is also one or more pair of the secondaries in the cardinal quadrants. Such thickening, however, is not recognized in the primitive species, or at least is very much less marked. In the genotype the total number of thickened septa is 7, these being interpreted as the counter, the alar and a pair each of the secondary septa in the counter and the cardinal quadrants, these in all cases being among the later ones of each series. The cardinal septum is short, producing a fairly well-marked cardinal fossula, even at an early stage. Tabulae well developed, more or less strongly arching in the center, often irregular and with an incipient siphonofossula in the region of the cardinal septum. Genotype *Plerophyllum artiense* Sochkine. Known range: Permian.

Sochkineophyllum artienne (Sochkine)

Text-Figs. 12 a. b.

1925. *Plerophyllum artienne* Sochkine. Bull. Soc. Natur. de Moscou. Sect. Geologique, p. 91, Pl. II, figs. 12, 12a.

Simple corals of conico-cylindrical form, with well developed epitheca showing in the lower part the costal grooves, though as a rule rather faintly. The transverse section is round and shows a series of unequal septa. In the adult there are 7 of these which reach nearly to the center, and are thickened more than the others. One of these, the longest, reaching quite to the center, is designated by Sochkine the counter septum. But if this is the case, this species is hardly referable to the genus *Plerophyllum*, but suggests rather a modification of *Lophophyllum*. The next two large septa are designated the alar, and if this is correct the result produced is a retardation of the counter quadrants, a fact pointed out by the author of the species. These quadrants have six secondary septa of which the third from the counter is the longer. In like manner the cardinal quadrants, following the designation of Sochkine, are characterized by 7 secondary septa each, of which the 3rd and the 6th are the longest and are thickened like the alar and counter septa. On the other hand, the designation given in Text-Fig 12a, seems to us more correct, and brings this coral in line with others of the kind. The cardinal septum is short resulting in the production of a marked fossula. Tertiary septa are very short and in some cases scarcely visible. The longitudinal section shows the presence of tabulæ which extend across the entire corallum. They are strongly convex, rising in the center around the prolonged counter septum, which gives the effect of a columella without this actually being developed. Dissepiments as such appear to be wanting, although the sections of the arched tabulæ give that appearance.

In a series of sections of 3 individuals Sochkine finds the following relation between the diameter and the number of septa (the designation is modified by separating primaries and secondaries).

- | | | | | | | | | |
|----|----------|--------|---------------|---|-----------------|-----|----------|-----|
| 1. | Diameter | 14 mm. | Primary septa | 4 | Secondary septa | 20, | Tertiary | 24. |
| 2. | „ | 16 „ | „ | 4 | „ | 22, | „ | 26. |
| 3. | „ | 21 „ | „ | 4 | „ | 24, | „ | 28. |

Sochkine enumerates the differences between his species and *P. australe* Hinde as follows:

- (1) The greater size; (2) presence of 7 instead of 5 strongly developed septa; (3) the strongly developed counter septum; (4) in the cardinal quadrants the longest and strongest pair of septa is that next to the last. From *P. cyathophylloides* Gerth, the Russian species differs in: (1) The absence of constrictions and rejuvenations. (2) The stronger development of the cardinal fossula. (3) The fainter develop-

ment of tertiary septa. (4) The well developed tabulæ, a feature also differentiating it from the Australian species. (5) The leaf-like thickening of the longer septa at their inner extremities.

HORIZON AND LOCALITY. In the Artinskian (mid-Permian) of the Lytva river, Government of Perm, Russia.

REMARKS: It is difficult to see how this type of structure can be in harmony with that of the typical forms of *Plerophyllum*. Certainly this is not possible if we follow Sochkine and regard the long septum as the counter, and this seems the most normal interpretation, for it is the only septum which reaches the center and gives a suggestion of the beginning of a median pseudo-columella. Even if we considered this longer septum the cardinal, the development does not correspond to that of *Plerophyllum*, for in that case it would not be the 1st but the 2nd pair of secondaries which is enlarged. Finally the prominent development of the tabulæ in this species is inconsistent with the known characteristics of *Plerophyllum*. These tabulæ are suggestive rather of the conditions seen in *Thysanophyllum*, but here again the lack of an external vesicular zone forbids the reference of this species to that genus. It would thus appear imperative that this species be referred to a distinct genus, and the generic name *Sochkineophyllum* is applied as a tribute to the Russian student of these corals who first made them known, and who has shown a full appreciation of the modern methods of the study of coral morphology.

The second species described by Sochkine appears also to be referable to this new genus, but presents apparently a less specialized type.

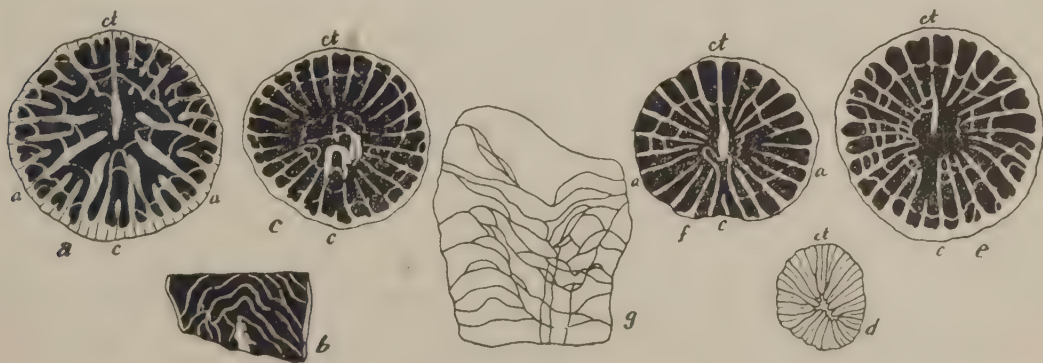


Fig. 12. Typical species of *Sochkineophyllum* from the Permian of Russia. All enlarged. a-b. *Sochkineophyllum artiense* (Sochkine); a, cross-section; b, longitudinal section of the genotype; c-g *Sochkineophyllum tenuiseptatum* (Sochkine), c transverse section of a corallum; d young stage of same individual; e. the same individual at an immature stage; f. section of another individual with strongly enlarged counter septum; g, longitudinal section of the same.

(Redrawn after Sochkine with lettering added; a, a, alar septa; c, cardinal septum; ct, counter septum)

Sochkineophyllum tenuiseptatum (Sochkine)

Text-Fig. 12 c-g.

1925. *Plerophyllum tenuiseptatum* Sochkine. Bull. Soc. Natur de Moscow, Sect. geologique page 92
Pl. II, fig. 8-10.

These corals begin as strong more or less curved cones continuing thus for a length of 2 or 3 cm., after which they become cylindrical, often angular or more or less knobly. The epitheca is thick showing wrinkles and lines of growth. (The septal grooves rarely show except in the basal part). Because of the crushed character of all the specimens, the nature of the calyx has not been determined. In section the pinnate arrangement of the septa is generally shown, there being a certain amount of irregularity among the longer septa, as well as a certain amount of attachment of the younger to the older septa. In the conical part the septa reach the center, whereas in the cylindrical part the central area is largely free from them, except for the fact that the counter septum continues to the center where it is somewhat thickened as it is in the primitive forms of *Lophophyllum*. None of the other septa are markedly thickened, nor is it possible to differentiate readily the alar septa. The cardinal on the other hand is recognized as a strongly aborted septum producing a fossula even at a very early stage. In the young form, however, alar septa are recognizable by their larger size and the relation of the other septa to them. Here it is seen that there are from 4-5 secondary septa in the counter quadrants and 3-4 in the cardinal. In a somewhat larger section (our text Fig. 12f) the counter septum is very pronounced and *Lophophyllum*-like and the alar septa may be recognized by the fact that they are somewhat longer than the counter secondaries next to them. Here there are 6 secondary septa in each counter quadrant and 4 in each cardinal, thus showing the Streptelasma-type of acceleration. This feature too, differentiates it markedly from the preceding species, if we consider that the septal orientation given by Sochkine is correct. If, however, we regard the intermediate pair of long septa (see our text fig. 12a) as the alar, these two types would harmonize much more. In that case, there would be 9 secondary septa in the counter quadrants, and 4 in each of the cardinal quadrants. One pair of the cardinals, that is the 3rd, is strengthened and lengthened and 1 pair of the counter secondaries, that is the 7th, is lengthened and thickened. Which of the two interpretations is correct will have to be determined by a study of serial sections or else by the method of Gerth, namely the removal of the epitheca, and the determination of the order of septal appearance from their exposed ends. A suggestion that the second rather than the first interpretation is correct is made because of the fact that in the present species (*S. tenuiseptatum*) the 4th secondary septum in the counter quadrants is stronger and longer than the 5th and 6th (see Text Fig. 12t).

Longitudinal sections of *S. tenuiseptatum* show the calyx to have a depth varying from 4-9 mm. The tabulae are irregular and discontinuous but numerous and forming a suggestion of a syphonofossula. Their distance apart ranges from 1-4 mm.

Sochkine gives a table of measurements of many individuals. The longest of these has a length of 90 mm, with a maximum diameter of 11 mm and 20 long septa. The largest number of septa recorded is 29 with a diameter of 24 mm, the section being that of a cone 20 mm from the base.

HORIZON AND LOCALITY: In the Artinskian beds of the Litva River, Gouvernement of Perm, Russia.

CHINESE SPECIES

Sochkineophyllum kansuense Grabau (sp. nov.)

Pl. III, Figs. 2a-2e.

This species is represented by a series of transverse sections all taken from a single specimen.

The holotype and only known specimen, before sectioning, showed a conical form with a rate of expansion in diameter of 3 mm in 10 mm of length. The epitheca showed concentric wrinkles and fine growth-lines, but the septal grooves and interseptal ridges were visible only in weathered portions.

SECTION A. (Pl. III, Fig. 2a): This has a diameter of 7.6 mm. There are 28 long septa in all, including 24 secondaries. They are all radial, though at one end the septa are shorter and more thickened. The middle one of these is slightly longer, and those adjoining it on either side are somewhat inclined towards it. It apparently represents the cardinal septum, though from the fact that the exterior is not exposed, it is not possible definitely to assert this. The 5th long septum from it on either side reaches the center, while the 6th on either side joins the 5th midway of its length, the remainder of the septa being free. This suggests that the 5th septum is the alar septum, which would leave 4 secondary septa on either side. The counter (?) septum opposite the assumed cardinal is one of a group of slightly longer septa, none of which, however, reach the center, and several of which are involved with the sections of the tabulae. If this orientation is correct, each of the counter quadrants has 8 secondary septa, all of which are long and taper to an edge, except the last which, as already stated, joins the supposed alar. Tertiary septa are well developed, especially in the counter quadrants, though even in the cardinal, they sometimes reach a considerable length. In some cases, the septa appear to have a median

swelling, hollow within, though this effect may be produced by dissepimental tissue. Dissepiments are fairly numerous and subregular, and, in the outer zone, they sometimes have the appearance of cystosepiments. The tabulae appear to be irregular, giving a coarse cystiform structure to the central area in the cross-section.

SECTION B. (Pl. III, Fig. 2b): This has a diameter of 12.2 mm, but is imperfect. The counter septum is very prominent, 7.3 mm long, and thus reaches beyond the center, though the dorso-ventral diameter may be somewhat greater than the transverse which alone is preserved. The inner end of the septum is slightly thickened or knob-like. One of the counter laterals adheres to it; the other is free, but several other septa appear to conjoin. The secondary septa are mostly short, reaching less than half-way to the center. They are thickened in their outer part but taper inwards to a point. This is, however, true of one side only. On the other they appear of uniform thickness throughout, or indeed are slightly thinner in the outer vesicular zone. Tertiary septa are for the most part well developed and so is the dissepimental structure, which is somewhat cystiform in certain sections.

SECTION C. (Pl. III, Fig. 2c): This has a diameter of 12.3 mm, being thus somewhat smaller than the preceding one. There are 35 long and one short (the cardinal) septa, besides the tertiary. Many of these longer septa are considerably thickened in their middle portion though their outer part, lying within the vesicular marginal zones, is thin and irregular and sometimes almost obsolete. The counter septum is continued in a long flagellum-like extension which has a sigmoid curvature and is located upon one side reaching far beyond the center. The point of junction between the flagellum and the main septum is very thin and it is not impossible that this apparent prolongation of the septum is due to a fortunately aligned section of a tabula, though the section itself gives no evidence of that. None of the other septa show much differentiation, except the cardinal, which is much shorter than the others, and there seems to be an interruption in the peripheral zone. Between the cardinal and counter septum there are 17 septa on each side, but the alar are not distinguishable; hence the relative acceleration is not apparent.

SECTION D. (Pl. III, Fig. 2d): This has a maximum diameter of 13.5 mm, and a minimum of 11.5 mm. The counter septum is long, reaching to the center where it becomes involved with the cystiform tabulae. Several other septa are long and join the central area in the same way, but there is no regularity in this matter. There appear to be 14 secondary septa on each side or 28 in all, making 32 with the primary septa. One side of the section, however, is imperfect and the full number of septa therefore cannot be ascertained. The periphery is formed by several rows of dissepiments and cystosepiments, the thickness of the zone varying up to 1.5 mm.

In some cases the outer septal ends seem not wholly to reach the periphery, but are interrupted by the outer row of vesicles. Several more distant rows of dissepiments occur in the intermediate portion, while the central area is marked by elevated tabulae which produce a coarse cystose structure in section. None of the septa are perceptibly thickened. The tertiary septa are slender and usually do not extend beyond the vesicular peripheral zone.

SECTION E. (Pl. III, Fig. 2e): This has a maximum diameter of 14.7 mm. There are 32 long septa which reach about $\frac{2}{3}$ of the way to the center, or somewhat less, and a broad gap with a shorter septum making 33 in all. This shows an irregularity, leaving 29 secondary septa, but since all are radial, with one exception, it is not possible to determine their disposition.

The counter septum is not recognizable, though one of the septa shows a slight extension as a very tenuous thread among the sections of the tabulae. One septum is shorter than the others but it is not opposite the longer septum. It may be the cardinal. Nor are the alar distinguishable. Hence there is no way of determining the degree of acceleration of the counter quadrants. Many of the septa are thinned or fade somewhat among the marginal dissepiments and cystiform structures. The sections of the tabulae form rather coarse incomplete vesicles, showing moderate arching at this point. Tertiary septa are fairly well developed.

This species is easily distinguished from *Sochkineophyllum tenuiseptatum* (Sochkine) (*Plerophyllum tenuiseptatum* Sochkine) by its greater number of septa, the Russian species of the same average diameter (13-15 mm) having only from 22 to 24 septa, while even much larger specimens have only 29 septa (24 mm diameter), or 27 septa (25 mm diameter). In the Chinese species the number is half again as great in specimens of the same diameter. The cardinal septum too of the Chinese species is not shortened to the same degree, though it is sometimes incomplete. The counter septum, though as long, is never so thickened as in the Russian form, though slight thickening may occur. Tertiary septa are also more fully developed in the Chinese species. A most significant difference, however, is the vesicular peripheral zone formed by cystosepiments and dissepiments in which the outer ends of the septa are sometimes lost. In this respect the coral approaches *Thysanophyllum* and indeed it is not impossible that this species is transitional, and perhaps ancestral to, some form of *Thysanophylloid* coral.

Neither this species, nor the form described by Sochkine as *Plerophyllum tenuiseptatum* shows the typical *Sochkineophyllum* characters which consist in the thickening of a certain number of the septa (See ante p. 75). For the present, however, they will be retained in that genus.

HORIZON AND LOCALITY: In the Yanghukou formation (Moscovian) of Yang-hukou, Shantan hsien, Kansu loc. 561, P. L. Yuan Coll. 1 specimen. Cat. Geol. Surv. China, 1579.

Family **LACCOPHYLLIDAE** Grabau (Fam. nov.)

Simple corals with the septa pinnate and in quadripartite position in the young or primitive forms, but quickly uniting at their inner ends to form a true inner wall or phyllothea which encloses a cylindrical or slightly enlarging tube generally divided by horizontal tabulæ. This wall may contract to leave some septa free. Dissepiments as a rule sparingly developed. Earliest forms in Silurian, latest in Permian.

Genera *Laccophyllum* Simpson (1900) *Alleynia* Pocta (*Nicholsonia* Pocta) (1902) *Barrandeophyllum* Pocta (1902); and *Permia* Stuckenberg, 1895.

Genus **LACCOPHYLLUM** Simpson

1900; Simpson: Preliminary descriptions of new genera of Palæozoic corals, Bull. N. Y. State Mus. No. 38, p. 201, figs. 7-9.

This genus was created by Simpson in 1900 with *L. acuminatum* Simpson of the Niagaran group of Perry County, Tennessee, as genotype. His definition of the genus is as follows:

"Corallum small, simple, cylindrico-conical, sometimes slightly curved, septa strong alternating in size, the larger ones continuing to within a short distance of the center, where their extremities become broadened and fused, forming a distinct inner wall, leaving a cylindric central space; the smaller septa about one-third the distance to the center, coalescing with the larger ones; tabulæ present, those of the inner space strong, horizontal; of the peripheral space much thinner and ascending from the outer to the inner wall, sometimes subcystose".

The genotype *L. acuminatum* Simpson (Text-Fig. 13) has a height of from 15 to 18 mm and a calicinal diameter of from 6 to 9 mm. On the exterior, which is more or less regularly conical, the septal grooves are well marked, showing the typical pinnate arrangement in their mode of increase, while at the same time there are stronger growth-lines which have the appearance of slight constrictions. There appear to be about 19 major septa, which in the section given by Simpson show a slight twisting, though this may be of no significance. They join, however, in the much thickened wall, which is augmented by secondary stereoplasm. That the wall is formed by the bent-over and united inner ends of the septa, hardly admits of any doubt, since that is the usual manner of formation of such a wall. It is true that Stanley Smith has described the formation of a similar wall in the genus *Aulina* S. Smith* by the spreading of the septa in a T-shaped manner and the fusion

* Quart Journ. Geol. Soc. Vol. 72, pt. 4 p. 291, 1917.

of the spread ends, but as that is a highly specialized Carboniferous coral, we may consider that the manner of formation of its inner wall is also specialized and therefore probably not characteristic of the earlier Palæozoic corals. Moreover, the return to the primitive condition seen in the last stages of *Alleynia* (*Nicholsonia*) *perfecta*, referred to below, indicates that the union of septal ends was the manner of formation of the inner wall in that related genus.

Such being probably the case, we must regard the thick character of the inner wall in *Laccophyllum acuminatum* as due to the deposition of secondary stereoplasm. The inner tube formed by it is traversed by well-formed horizontal tabulæ which produce rather irregular spaces, by being more crowded in the upper than the lower part. Dissepiments seem to be rather numerous, although not shown in Simpson's cross-section. In the longitudinal section, however, they appear in the interseptal loculi as delicate plates ascending from the wall towards the tube. They are mostly of a very delicate character and frequently anastomose, though they are never truly vesiculose. Although they have the appearance of tabulæ in this section, they are not truly such and their designation by that name in Simpson's description is misleading.

One of the features which indicates the primitive condition is the adherence

of the tertiary septa to the secondaries, which thus appear to be bifurcating at their outer ends. A few septa are without such secondaries but it is not possible to say whether they represent the primaries. It is a simple enough matter to locate the cardinal septum from the costal grooves on the exterior, but from the section it is not possible to determine it, nor does the counter septum appear to have the usual trident arrangement due to the junction with it of the tertiary septa on either side. Nor is this structure seen in any of Pocta's sections of the other corals of this group, but judging from the early section of *Barrandeophyllum perplexum* Pocta (pl. 108, fig. 4), the cardinal septum becomes aborted at a very early stage.



Fig. 13 *Laccophyllum acuminatum* Simpson. Lateral view of a corallum, natural size; transverse section showing the septa and the inner wall, enlarged; longitudinal section showing central tube with its horizontal tabulæ and the tabuloid dissepiments in the interseptal loculi. Niagaran group, Perry Co., Tenn. (after Simpson).

This is also stated to be the case in the early stage of *Alleynia* (*Nicholsonia*) *perfecta*.

Genus **ALLEYNIA** Pocta*(Nicholsonia* Pocta in Text)

1902: *Nicholsonia* Pocta, Anthozoaires et Alcyonaires. In Barrande, Syst. Sil. du Centre de la Bohême, Vol. VIII, Tome II, pp. 184 *et. seq.*

(The name *Alleynia* was substituted in the description of the plates, as *Nicholsonia* had been preoccupied for a genus of the *Heliolitidae*).

Pocta has erected the genus *Alleynia* (*Nicholsonia*) for small corals from the Silurian and Devonian of Bohemia, using *Petraia bohémica* Barrande as the genotype. The species described are the following:

A. (N.) bohémica. (Barrande) from beds g 1 and g 2. (Text-Fig. 14 ab)

A. (N.) curta. Pocta, bed e 2.

A. (N.) major Pocta. e 2.

A. (N.) nana (Barrande) e 2.

A. (N.) perfecta Pocta e 2. (Text-Fig. 15)

All the species are as a rule minute, conical or turbinate. They contract laterally towards the base and sometimes are a little curved. Epithecæ well developed except where destroyed before or during fossilization. Septal grooves well developed and showing normal pinnate arrangement of the simple tetrseptate corals. The cardinal septum is sometimes shown on the interior of the coral, but this is not common, for in most cases the septa are radial. Although the thin border of the calyx of most of the specimens is broken, it is nevertheless possible to ascertain that the depth of the calyx was as much as two-thirds the height of the total corallum, the septa forming low ridges on its inner margin. The mass of the endothecal structures is restricted to the lower third of the corallum.

The number of septa varies from 18 to 24 though sometimes the number is increased to 40 or 48. They are always of two different sizes. They are generally much thickened by secondary stereoplasm, which also thickens the epithecal wall. In the center the septa unite to form a median cylindrical tube, which in all cases is hollow and is indeed to be regarded as a true phyllotheca. It is always joined to the wall of the corallum by small supporting beams of sclerenchyma. The empty spaces or lacunæ surround this central tube. Sometimes the basal portion, however, as well as that within the tube, is entirely filled by stereoplasm. Within the central tube, which Pocta wrongly

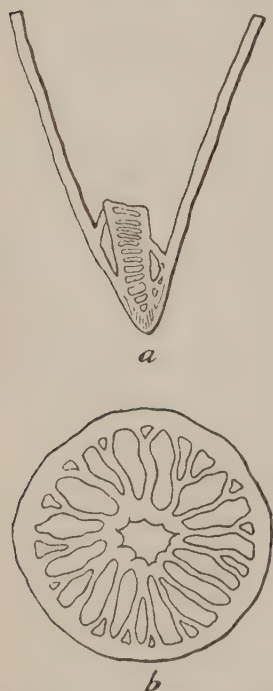


Fig. 14 *Alleynia bohémica* (Barrande) Pocta. *a* longitudinal section, showing tube *b*, transverse section much enlarged; Middle Dev. g 1 and g 2 Bohemia (after Pocta).

denominates a pseudo-columella, the space is divided by many horizontal tabulae, this structure being particularly well developed in *A. bohémica* (Text-Fig. 14), *A. nana*, and *A. perfecta* (Text-Fig. 15), the first of which is the genotype. In many cases there is considerable thickening of the inner tube by deposition of stereoplasm between the inner ends of the septa as is especially shown in *A. nana*, while in *A. curta* the reverse seems to be the case, the central tube being but slightly developed while the amount of stereoplasm is not very great. In all cases the tertiary septa are joined to the secondaries, but in the majority of forms the latter are not distinguishable from the primary.

In one species, however, *A. perfecta*, from division e 2, a remarkable feature is found. This is a small species, the height being only from 12 to 15 mm, and the maximum diameter from 6 to 10 mm. The epitheca is thin and sometimes worn away, when the pinnate arrangement of the septa is well shown. This pinnate arrangement of the septa is also well shown in the upper part of the corallum, that is, in the calicinal floor, (Text-Fig. 15). The cardinal septum (c) is thin and elongated, there being apparently 3 secondary septa in each adjoining quadrant, these uniting at their ends. The alar septa are also free, as are also at least 3 of the septa of the counter quadrants, all, however, being modified by tertiary septa which commonly adhere to them. The counter septum is joined by two very large tertiary septa and outside of this by the first pair of counter laterals, each of which is further modified on the outside by a tertiary septum. Thus the group opposite the cardinal septum is made up of five large septa conjoined and ending in a rather thick inner point, or of 7 in all if we count the two outer tertiaries. Altogether there appear to be 4 secondaries in the counter quadrants as compared with 3 in the cardinal quadrants.

Such is the character of the septa in the upper part of the corallum,



Fig. 15 *Alleynia perfecta* (Bar-
rande) Section much
enlarged C=cardinal sep-
tum. Silurian e 2 Bohemia
(after Poeta).

but towards the base the arrangement becomes modified in a most remarkable manner. The septa are united towards the center to the median deposit of stereoplasm, the cardinal septum disappears, being replaced by a fossula or vacant space. The other septa unite by their inner ends to form an horse-shoe-shaped tube, extending from the center of the calyx to the periphery at the fossula. Such a tube normally precedes the formation of the closed inner wall and is characteristic of such genera as *Craspedophyllum* and *Hapsiphyllum*. In the present species such an open tube is the normal, but sometimes it is closed at the fossular end, forming a truly complete inner wall, such as is typical of *A. bohémica*.

We have here a most remarkable succession of characteristics. Ordinarily in the development of types with an inner wall, the quadripartite arrangement

of the septa with the junction, by their inner ends, of the secondary septa of each quadrant, appears in the young. In the present case it appears in the adult. Normally the open inner wall, develops next, to be followed by the closed inner wall. In the present case the open inner wall is normal in the young, becoming occasionally closed, but these stages in either case precede the one comparable to the normal primitive stage. It would appear that the only interpretation of this condition is that the present species represents an exceedingly accelerated form in which the later stages again return to the primitive condition. Such return must then be regarded in the light of a degeneration. This is all the more remarkable because this coral belongs to the upper part of the Silurian, whereas in the type species from the Devonian, the tube stage continues into the adult. There is one other Silurian species, *A. major*, which resembles this remarkable form, but with the characters less pronounced. This coral is about twice the size and has 24 large septa.

So far as the general characters are concerned there seems little reason to doubt that *Nicholsonia* or *Alleynia*, as it is more properly called, and *Laccophyllum* are congeneric, in which case the latter name has priority. The fact that the American species belongs to the same geological horizon as the majority of the Bohemian species, and that this horizon represents a period when the Boreal coral fauna was widespread in Europe and America, would indicate that they are derivatives from the same Boreal stock. This type has not yet been observed among the Asiatic Silurian corals, but since the Boreal fauna likewise invaded the Asiatic geosynclines in Niagaran time, there is every reason to believe that the type will eventually be discovered in this country. That it continued into Lower Middle Devonian or Eifelian time, is shown by the type species *A. (N.) bohémica* and by the modified *Barrandeophyllum perplexum*. The latter probably deserves distinctive generic designation even though *Alleynia* should prove to be synonymous with *Laccophyllum*.

These types are sufficiently distinct in structure to deserve placing in a separate family, but we cannot follow Pocta in joining them to the very different genus *Lindstroemia* in the family LINDSTROEMIDÆ. Since the genus first proposed by Simpson is the most definitely established, it would seem proper that we designate this family by the name LACCOPHYLLIDÆ (Family nov.).

Genus **BARRANDEOPHYLLUM** Pocta

(Text-Fig. e 16)

1902: Pocta: Anthozoaires et Alcyonaires, in Barrande, Syst. Sil. du Centre de la Bohême, Vol. VIII, Tome II, pp. 190 et seq.

This genus was created by Pocta for a small species of simple coral from the Lower Devonian (g 1) of Bohemia. The general form and character are like the preceding type, the surface being covered with an epitheca which shows the septal grooves. The calyx is of moderate depth, the septa appearing as feeble ridges on its side, but it is only in the lower part that they stand out strongly. There are 26 long major septa and an equal number of shorter and thinner ones alternating with them in the typical species. Generally these tertiary septa adhere to the others, but sometimes they are free. When conjoined they produce the appearance of bifurcating septa. At a 4th of the height of the specimen above the base, the septa unite by their extremities to form a large central tube, without, however, the development of secondary stereoplasm, or if such is formed, it is of minimum amount and it does not re-enforce the thickness of the tube, which is scarcely thicker than the septa. The septa, united into the central tube, do not show any pinnate arrangement and it has been impossible to determine whether the septa again become free in the upper part of the calyx as is the case in *Alleynia perfecta*, since the genotype is represented by only one specimen.

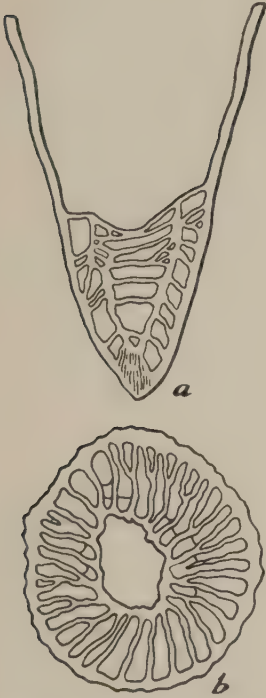


Fig. 16 *Barrandeophyllum perplexum* Pocta; a. longitudinal section; b. transverse section. Lower Dev. Bohemia. (after Pocta).

In longitudinal section (Text-Fig 16 a) the coral shows the pronounced median tube formed by the union of the inner ends of the septa. The wall of the tube is thin, without stereoplasm and the central space is divided by horizontal tabulae of more or less regular occurrence and horizontality, so as to produce rectangular spaces in section.

The basal part of the tube is not generally seen in these sections. It appears to be joined to the epitheca by a series of bars which are often ramifying.

Judging by analogy, however, and the conditions seen in *Alleynia perfecta*, the younger stage of the corallum would show the primitive tetrameral arrangement seen in all the corals of this group. The conjoined ends of the septa gradually develop into sections of the inner tube which is completed by the formation of dissepimental bars across the alar and cardinal gaps. These features however, are highly accelerated in the corals of this type, so that the tube is completed at a very early stage. A section of a very early stage of a specimen of *B. perplexum* shows indeed a bilateral arrangement of the septa, with the united ends suggesting the horse-shoe-shaped wall opening to a cardinal fossula. So far as may be judged from the illustration, the cardinal septum has really become aborted at this stage.

The development of dissepiments is not very uniform. Sometimes they are moderately abundant, in other cases they are found only between occasional septa. When numerous, they form in section a succession of tabula-like structures which may be quite regular and rise obliquely from the wall to the inner tube. This is the type of structure which appears to be especially well developed in Simpson's genus *Laccophyllum*. Genotype *B. perplexum* Pocta Lower Middle Devonian g. 1 Bohemia.

The chief difference between this genus and *Alleynia* is according to Pocta the absence of the secondary stereoplasm and its strong development in *Alleynia*. It might be questioned whether this feature is sufficient to be of generic value, but taken in conjunction with the fact that the inner tube of *Barrandeophyllum* widens rapidly while that of *Alleynia* from the same horizon is more nearly cylindrical, the distinction may be upheld as representing two diverging types. It is quite possible however, that *Barrandeophyllum* is a derivative of the Silurian *Alleynia* as is the *A. bohémica* of the Lower Devonian.

CHINESE SPECIES.

Barrandeophyllum choniukounense Grabau (sp. nov.)

Pl. II, Fig. 19 a to e.

The Holotype of this species (Pl. II, fig. 19 a to e Cat. 1575) is a small conical coral with a length of 15.5 mm and a maximum diameter of 10.9 mm, the other diameter at right angles being 9.7 mm. This is the measurement at the calyx, but lower down the section is nearly circular, the corallum being very gently curved in the lower part, but scarcely so in the higher. Epitheca with lines of growth and a few wrinkles in the terminal part. The septal grooves, however, are not well

marked except on the side shown in Fig. 19a where the coral is slightly worn and exposes the septal ends. Hence it is not possible to determine with exactitude the location of the primary septa.

In a section of the lower part, where the diameter is 5.5 mm the total number of septa appears to be 20, all of which are strongly thickened by stereoplasm. At their inner ends they unite into a thickened tube, the outer diameter of which is 1.7 mm and the inner, though somewhat irregular, is about 1.1 mm. leaving 0.6 mm for the double thickness of the wall which thus has an average thickness of 0.3 mm, though there are some variations. A few dissepiments occur in the interseptal loculi, but otherwise they are hollow.

A section somewhat higher (Pl. II, fig. 19c) has a diameter of 7 mm, and shows 23 septa, all of them much thickened by stereoplasm. There are no tertiary septa, and dissepiments are very rare. The inner area has a diameter of 2.3 mm, but the inner tube has a diameter of 1.5 mm. giving an average thickness of 0.4 mm to the wall. The wall does not seem to be complete in every part, but formed locally by the close juxtaposition of the thick ends of the septa.

A third section is 4 mm higher than the preceding and in this the maximum diameter is 9.5 mm and the minimum 8.9 (Pl. II, fig. 19d.) In this the septa are very short, the inner tube having greatly enlarged and having become rather irregular. Its greatest diameter is 6.5 mm while the diameter at right angles to this is 4.6. The wall of the tube is now of very moderate strength, not exceeding 0.5 mm in thickness. It is very clearly formed by the bent-over edges of the septa, though even here it occasionally appears to be incomplete, while the length of the septa forming it varies greatly on opposite sides of the corallum. The character of the tabulae on the interior, if they are present, has not been ascertained. A single ring of dissepiments appears to be present. There are 24 septa.

The calyx of this specimen is somewhat contracted and oval in outline, with the cardino-counter axis the shorter. The counter septum seems to be the strongest and is flanked on either side by a shorter septum which joins it and which may be tertiary. The cardinal septum appears to be somewhat longer than the others which reach a little more than $\frac{2}{3}$ of the way to the center, this being occupied by a flattened space apparently tabuloid. The union of the septa is not marked in the calyx but appears in the section a short distance below.

Another specimen of this same species from the same locality (Cat. 1642) was sectioned about 6 mm above the base, which latter is marked on one side by a broad scar of attachment. The diameter of the section is 7.2 mm. The septa

are radial but the character of the center is not observable because of crystallization. There is, however, a ring of strong dissepiments in one half of the coral, producing a crescentiform zone, thickest in what appears to be the counter region. This zone has the appearance of an inner wall, but the septa are clearly seen to extend beyond it.

A millimetre or more above this, however, where the coral has a diameter of 8.6 mm, the inner wall is distinctly seen, the area enclosed by it being somewhat irregular, but having a diameter reaching 2.7 mm. Here too, the outer zone of dissepiments is clearly seen.

In the calyx, the inner zone is distinctly marked by an abrupt depression, whose diameter is 3.5 mm, and whose depth is considerably over 4 mm, the calicular wall being imperfect. The septa are radial, extending to the inner area which appears to be central and essentially circular. The septa are thin, widely spaced and joined by several rows of dissepiments. Short tertiary septa are present.

HORIZON AND LOCALITY: From the basal part of the Choniukou Formation of the Viséen, at Wuweih sien Kansu, P. L. Yuan coll. Geological Survey, China. Cat. 1575.

Barrandeophyllum compressum Grabau (sp. nov.)

Plate III Figs. 8a-d and Pl. VI, Figs. 12 a-c.

Corallum short conical, scarcely curved and then irregular, rapidly expanding and laterally compressed into an oval outline, in the later portion, although the young is essentially cylindrical. When well preserved, the septal grooves are deep and sharp, with the intervening ridges strongly rounded as shown in Pl. VI Fig. 12a. The pinnate arrangement of the septa is well shown in these grooves. Sections of an individual (Cat. 1576, Pl. III, Fig. 8) in which the growth is somewhat irregular, show a circular outline in an immature and an oval in the mature stage. The immature section (Pl. III, Fig 8c) has a diameter of 6.4 mm, and shows the septa radially arranged, uniting on the inside to form the wall of the tube which has an average diameter of 1.7 mm, but is rather irregular, almost quadrangular in form. On one side it seems to be incomplete but here the septa themselves are in actual contact. All the septa are strongly thickened by secondary stereoplasm so that they are in contact laterally or at least by their inner half, while between them in their outer part the interseptal loculi, which remain open, are very small, and of tear-drop outline. The septa are distinctly differentiated from the secondary stereoplasm, and the central

line of the septa, in some cases at least, appears to end freely, while in others it may be seen distinctly to bend over and take part in the formation of the inner tube. For the most part, however, this resembles, and appears to be made up of a secondary stereoplasm, its width equalling the width of the deposit on one side of the septum, the septa thus being twice as thick as the inner wall and also thicker than the outer wall. What seems to be the cardinal gap of the wall, is closed by a short horse-shoe shaped connection between the ends of two of the septa, enclosing a 3rd one between them which seems to be the cardinal, but this cannot be positively ascertained. This connecting loop projects into the cavity of the inner tube, thus marring its normal outline. The total number of septa is 22, leaving 18 secondary septa, apparently distributed 4 in one group of quadrants, and 5 in the other, but which of the quadrants are the accelerated ones cannot be determined. There are no indications of tertiary septa in the section, though the septal grooves indicate their incipient development. Dissepiments too are almost entirely wanting, but the central tube appears occupied by tabulae, though, owing to lack of material, sufficient sections could not be made to ascertain the character of these tabulae.

A small section 5.3 mm in diameter (Pl. III, Fig. 8b) has a rather irregular inner tube 1.8 mm in diameter. This is clearly formed by the bent-over inner ends of the septa which join. So far as the imperfect section permits determination the septa bend towards the counter septum in the counter quadrants, that is, each new septum apparently adhered to the preceding one until its continued growth produced the effect of a rectangular bend in the adhering portion. There appear to be 6 secondary septa in the counter quadrants, but since the section is imperfect, this can be only a tentative statement. All the septa are much thickened so that the interocular spaces merely have the tear-drop form and in some cases appear to be obliterated altogether. The central dark line of the original septum is, however, clearly visible in the thin section. Tertiary septa are apparently absent though in one part of the section the indentation of the wall between two secondary septa indicates the presence of a tertiary intercostal groove.

The third section (Pl. III, Fig. 8d) of the same individual was made 8.4 mm higher than section 8c. This is oval in outline and has a maximum diameter of 11.6 mm, this being the ventro-dorsal or cardinal-counter diameter, and a transverse diameter of 8.7 mm. The septa all end freely, the section here being through the calyx above the tube. They range in length up to 3.5 mm, but are mostly somewhat shorter. The longest ones are usually on the side while the end septa are usually only about half the longer ones. The cardinal and counter septa are situated on opposite ends of the oval, and the septa on either side are inclined towards them but rarely if ever

actually touch. The thickening of the septa is such as to give them a wedge-like outline, their inner ends appearing as fine tapering points in the section. The total number of septa is 25, leaving 21 secondary septa, but since the alar are not differentiated in form from the secondaries, their precise location is not readily determined. In this specimen, the exterior is worn so that the septal grooves are but faintly indicated. So far as these permit determination, the cardinal septum lies on the shorter or slightly concave side of the corallum and the cardinal quadrants have each 5 secondary septa, while one of the counter quadrants has 5 and the other 6. septa.

The calyx of this specimen is not fully preserved, nor is the interior sufficiently exposed to show the characters. The end diameters however are 12.3 mm for the maximum and 8.7 mm for the minimum.

Another specimen (Cat. 1577, Pl. VI, Fig. 12 a-c) shows a very rapid enlargement, this being from 4.5 mm in the circular stage to a maximum of 11.4 mm and a minimum of 8.5 mm at the point of section 8.7 mm higher. The calicinal diameter of this specimen is 16.6 mm for the maximum and 10.8 mm for the minimum. The total length of this specimen could not have been less than 2 cm and was probably somewhat more. The cardinal septum is on the rapidly growing side, the alar on the laterally compressed side. As before noted, the septal grooves are deeply impressed and the ridges between them strongly arched. Though in the section as a rule, tertiary septa are scarcely indicated, their presence is well shown by the costal grooves on the exterior. Thus in the youngest section of 4.5 mm in diameter, these grooves indicate that the tertiaries in many if not most cases are well developed, the total number of septa indicated by the grooves being 28, which if we allow 12 tertiary septa, would give us no more than 12 secondaries in addition to the 4 primaries or approximately 3 in a quadrant. The exact condition cannot be fully ascertained, but the central tube is seen to be essentially complete, and to have a diameter of about 1.2 mm. The septa too appear to be scarcely thickened.

Owing to the perfect preservation of the costal grooves, it is possible to ascertain the location of the principal septa in this specimen. The alars are situated near the centers of the flatter side, that on the left being either aborted or shortened by injury, while the right one is fairly well developed though not reaching the length of some of the secondaries. The cardinal septum situated at one end is somewhat shorter than the others but the counter is slightly longer than those adjoining it. All the ends of the septa are free and their maximum length is not over 2.5 mm though most of them are shorter. The total number of secondary septa is 23, each quadrant being provided with 6 fully developed septa with the exception of the right hand cardinal quadrant which has only 5. These septa are thickened only at their point of emerg-

ence from the thickened calicinal wall; they taper rather rapidly to a thread in section and are somewhat curved. The tertiary septa do not emerge beyond the thickened wall and are therefore not visible in the calyx.

A section 3 mm higher has a maximum diameter of 14.8 mm and a minimum of 10.4 mm (Pl. VI, Fig. 12 c.) The section is reversed with reference to the preceding one. The counter septum is long and irregular though much of the extension is broken. The cardinal septum is very short. There are 24 secondary septa, 6 in each quadrant, many of them reaching a length of 4 mm. They all end freely but nearly all of them have slightly swollen inner ends, while the greater part of their length is thin and only at their junction with the calyx wall are they triangular and strong. The tertiary septa only in very rare cases extend beyond the calicinal wall, being for the most part invisible.

HORIZON AND LOCALITY: Choniukou formation: basal portion; specimen Pl. III Fig. 8 (Cat. 1576), Upper middle part; specimen Pl. VI Fig. 12 (cat. 1577). Viséen Wuweih sien, Kansu. P. L. Yuan collector. Cat. 1576 and 1577.

Barrandeophyllum disjunctum Grabau (sp. nov.)

Pl. III. Figs. 1 a-d.

Corallum a moderately sized, somewhat irregularly expanding, gently curved cone, somewhat more than 3 cm in length and 15.5 mm in maximum diameter, though this does not include the calicinal rim which is broken away in the type specimen, so that the total length, and the depth of the calyx cannot be ascertained. The epitheca is marked by growth-lines and by several coarse constrictions, while the septal grooves are only faintly marked, though not sufficiently so, to permit the determination of the principal septa. The internal structure is rather remarkable as shown by a series of cross-sections.

In a section (Pl. III, fig. 1b) 9 mm in diameter and approximately 9 mm above the initial point, there are 25 long septa, 24 of which are disposed in groups of 12 each united by their inner ends and the addition of the distinct layer of sclerenchyma which forms the walls of the inner tube. This tube is open at the cardinal end, where the cardinal septum freely projects into the aperture; the sides of the tube are somewhat irregular especially so on one side, where it is undulating because of the varying length of the septa. The tube is elongate-oval in outline, its transverse diameter averages about 1.8 mm, while its longitudinal diameter is 3.1 mm. Beyond this it is continued in the openings, which flank the cardinal septum. On the dorsal or counter

side it is also open and continued for a short distance, where it appears to be closed by the shorter counter septum which forms a solid structure, because of its stereoplasmic thickening and that of its two adjacent septa. Indeed all the septa are strongly thickened by stereoplasm so that the interseptal loculi are mostly narrow, elongate-oval, tear-drop form or even linear. The thickening of the septa is greater in the inner half and hence this is more or less a solid mass of stereoplasm, especially on one side of the corallum. It is not possible absolutely to locate the alar septa but as nearly as their position can be ascertained from the imperfect exhibition of the septal grooves, it appears that the number of secondary septa in the cardinal quadrants is 4, which would leave 7 to the counter quadrants. The distribution may, however, be 5 and 6 in the cardinal and counter quadrants respectively. Tertiary septa are indicated by costal grooves but do not appear in the section.

A section several mm higher (Pl. III, Fig. 1c reversed) has a diameter of 10 mm and shows the inner wall separated from the septal ends on the right side, (left in figure) but maintaining its integrity. It has a thickness of about 0.7 mm in the free part and consists of 2 outer dark layers and a middle lighter layer which is about equal in thickness to the combined thickness of the outer layers. The number of septa left free is 10, including the cardinal septum; 15 septa are still joined to the tube making a total of 25 in all in this section. The cardinal septum is long and joined by dissepiments to the two adjoining ones. The counter septum is not differentiated. On the other side the septa join the tube which is less marked than is the free portion. The septa on this side are more thickened on their inner ends than on the opposite side. Dissepiments are mostly lacking.

A thin, much shattered section, 12.5 mm higher as measured on the outside, has a diameter of 14.7 mm and shows still further modification in the same direction (Pl. III, Fig. 1d). There are 28 septa, with 24 secondaries. They are mostly united throughout by stereoplasmic thickening, though in a few cases interseptal loculi still appear. The tube has now become strongly contracted, the main wall extending through the center of the caliculus where it divides into two branches. The principal branch which is geniculate combines 3 septa on one side and 4 on the other, spreading out in finger-like fashion at either end. From the elbow, a short branch continues in the same direction as the main arm and combines the ends of two septa, thus there are in all 4 cavities, three on one side, varying in size and filled with crystalline calcite, appear to represent the open tube divided by two branches of the dissociated part of the inner wall*. In this case the septa opposite have their free

*Some of these characters may be due to irregular tabulae, though the presence of such has not been ascertained.

ends united by a continuous line of dark appearance which seems to represent the other side of the inner wall, still closely adnate to the septa. In the opposite cavity which is filled by a denser mass of calcite, the septa are also united but the dark wall which joins them penetrates more deeply between the septa, thus having an intensely scalloped appearance. This is apparently the same side as that which shows the free septa in the earlier section. The polished surface of the corallum above the section is shown in Fig. 1e, reversed.

Indications of tertiary septa are lacking both in this and the preceding section, though there are, as usual, septal grooves on the exterior indicating their incipient development.

This species is very marked and differs from all the other known ones in the peculiar character of the inner tube which appears to be at no time circular, but elongate, and which in the later stages becomes more or less independent. This suggests an approach to the conditions seen in the genus *Permia*. Since the calyx is however unknown it cannot be determined to what extent this tube may project into it.

HORIZON AND LOCALITY: Choniukou Formation of Viséen Age at Kankou, Wuweihsien, Kansu. P. L. Yuan collector. Holotype Cat. G. S. C. 1578.

Genus **PERMIA** Stuckenberg

1895. Stuckenberg - Korallen und Bryozoen der Steinkohlen Ablagerungen des Ural und des Timan (Mem. Com. Geol. X, No. 3, pp. 186, et seq. Pl. III, Fig. 6).

What is undoubtedly a distinctive generic type within the family *Laccophyllidae* as now constituted, is the genus *Permia*, described by Stuckenberg in 1895 with *P. ivanowi* Stuckenberg, from the Lower Carboniferous limestone of the West Ural as the genotype. It is said to be common. This coral consists of curved horn-shaped simple coralla, with a circular section, and reaches a length of 20 mm with a diameter of 15 mm, while the depth of the calyx in the type species is 8 mm. From the center of this calyx rises the upper end of a hollow tube which runs throughout and which has a maximum diameter of 2 mm, while the thickness of the wall is not over 1 mm. Stuckenberg speaks of this tube as a hollow columella, a designation which seems somewhat misleading, since it suggests similarity to the pseudocolumella of other forms. He states that this tube, which has a finely ribbed outer surface, arises from the base of the caliculus and projects 3 mm above the floor of the calyx. This certainly gives it the aspect of a columella, but there seems no reason to doubt, from the appearance of this wall in section and the

manner in which the septa join it, that in origin it is a true phyllothea, formed by the united bent ends of the septa and developed after the manner determined for *Crepidophyllum* and *Eridophyllum* as described on page 19, fascicle I, of this volume and as seems indicated in the case of the inner wall of *Alleynia* and other genera of the LACCOPHYLLIDÆ. That it rises above the center of the calyx and is of rather pronounced thickness can readily be considered a secondary feature. As stated by Stuckenberg and shown in his figure 6c on pl. III the tube is hollow throughout, lacking the tabulae found in the genera previously described. Toward the base in the section illustrated it appears solid, but this may be due to the direction of the cut. Stuckenberg merely states that it is tube-like and hollow. The major septa, of which there are 38 in the adult, are ridge-like on the inside of the calyx, but join the central tube below. The cardinal septum is distinguishable from the fact that it is partly aborted forming a fossula. It is situated on the convex side of the corallum. The tertiary septa 39 in number in the type, are fainter and recognizable only in the vicinity of the calyx. In a smaller specimen, in which the diameter is only 12 mm, the total number of septa including the tertiaries is 66. Septal grooves and growth-lines mark the epitheca.

There seems little reason to doubt that this coral is a late representative of the LACCOPHYLLIDÆ whose chief development is in the Silurian. The absence of tabulae within the inner tube is probably to be accounted for by the minuteness of the central hollow and is compensated for by the general thickening of the tube wall. Faint irregular dissepiments are suggested by the illustrations, but are not mentioned in the text.

ABERRANT LACCOPHYLLIDÆ.

Genus **RETIOPHYLLUM** Pocta.

1902. Pocta Anthozoa et Alcyonaires; pp. 180-181, Pl. 68, 108.

This genus was founded on two specimens of a small coral described as *R. mirum*, by Pocta, one from bed g 1 and the other from f 2 both in Bohemia. The corals are simple and small and very slender, their height not exceeding 20 mm and their form generally conical. So far as it is possible to judge from the material, the calyx is deep. The septa are clearly indicated on the outer wall by the costal grooves and seem to be very uniform, but on the interior of the corallum, the arrangement of the material is very irregular. They are of variable thickness, extending from the wall to an unequal distance and instead of being regularly radial, they extend in different directions, reuniting at the center of the corallum in such a way that the cross-section presents a tangled network in which one cannot recognize major or minor septa. These

structures as well as the connecting bars, which may be regarded as a sort of dissepiment, are nevertheless simple, very small and without any secondary deposits of stereoplasm. Where they join in the center they unite into an irregular central wall, which encloses a tube occupied only by irregular vesicular tabuke. One of the specimens described has in its lower part an excrescence which forms a sort of a stolon which in section shows similar structure to that of the corallum and apparently represents a bud.

In its internal structure this form approaches the genera *Alleynia* and *Barrandeophyllum* but those genera differ strikingly in their regular radiating septa, though in the center, they also unite into a cylindrical inner tube. It is because of the irregular septa that Pocta has placed this new genus in the family *Palæastræidæ* of Römer which includes the genera *Heterophyllia* McCoy and *Battersbyia* Edwards & Haime.

GENOTYPE: *R. mirum* Pocta, Devonian g1 & 2 of Bohemia.

Family **LOPHOPHYLLIDÆ** Grabau (fam. nov.)

Simple, but accelerated corals of the streptelasmoid type, with the counter septum reaching the center, where it is often thickened, sometimes excessively so, and frequently partly separated into a pali-columella in the upper part of the corallum. Secondary septa well developed, those of the counter quadrants more numerous. The first pair of counter secondaries or counter laterals appears very early by acceleration so as to seem to originate simultaneously with the 4 primary septa and erroneously give the young a hexameral appearance. Tertiary septa in more specialized types. Carinæ may occur, also in some cases a fossula by abortion of the cardinal septum, and sometimes the alar septa may be shortened too. Endothecal tissue sparingly developed in the more primitive, strongly so in the more specialized species, comprising more or less arched tabuke in the center and dissepimental, more rarely cystosepimental tissue between the septa and in the peripheral part.

Genera placed under this family:

Lophophyllum Edw. & Haime 1850 Dinantian-Permian

(*Lophophyllidium* Grabau (nom. nov.)

Lophocarinophyllum Grabau 1922 (This Volume Fascicle I p. 46)
Carboniferous

Sinophyllum Grabau (nov.) Perm.

Rossophyllum Stuckenberg 1888 Moscovian-Permian

Timorphyllum Gerth 1921 Permian

Koninckophyllum Thomson and Nicholson 1787

(*Lophophyllum* E. & H.?) Dinantian.

Genera **LOPHOPHYLLUM** E & H; and **KONINCKOPHYLLUM** Th. and Nich.

Genus **LOPHOPHYLLIDIUM** Grabau (nom. nov.).

In the Geological Magazine for February 1913 Carruthers discusses the genus *Lophophyllum* and calls attention to the fact that the genotype is *L. tortuosum* (Michelin) from the Tournaisian of Belgium. He gives a series of sections which clearly show that it is markedly distinct from the Carboniferous corals usually described under this genus, although these are in agreement with the type in having the pseudo-columella originate from the counter septum. In a series of cross-sections the following features are shown.

"All the septa extend to the epitheca throughout the coral, while in the younger growth stages there are no dissepiments although these appear later on, in a narrow ring next to the epitheca. The major septa extend to the thin lath-like columella (which is a direct continuation of the counter septum) until the final growth-stages; they then become amplexoid and fall away, leaving a bare tabular area in the center of the coral. Through this bare central area, the columella continues to project, surrounded by thin wavy lines, representing the edges of upraised tabulae, cut off by the plane of sections. At this stage the columella is often fringed with small projections, which are the remnants of attached septa; their length varies according to the proximity of the section to a tabula, the septa being always most fully developed on the upper surface of a tabula. The large cardinal fossula is especially prominent in the younger growth-stages, when it is expanded inwardly and completely enclosed by the major septa." (Carruthers page 51).

Vertical sections show the following characters according to Carruthers (p. 51)

"The tabulae rise steadily up to the columella, but there is no central zone, in which they are closer and more sharply elevated as in other Clisiophyllids (*Dibunophyllum*)."

"The columella is continuous throughout while the dissepiments are small forming a narrow outer ring of 2 or 3 rows only."

It is evident that these Lower Carboniferous corals, which have commonly been placed in the genus *Koninckophyllum* of Thompson and Nicholson are quite distinct from and more specialized than the later Carboniferous and Permian forms such as *L. proliferum* etc. which have commonly been considered as typical of the genus. These are clearly related to members of the family Straptelasmaidae, but *Lophophyllum tortuosum*, because of its well-developed tabulae cannot be referred to the same genus. It shows some relationship to the genus *Thysanophyllum* in typical forms of which, however the external zone is vesicular rather than dissepimental. Sochkin has however, figured and described a species under this genus (*T. tschernowi*) from the

Artinskian of the Urals, which in the adult shows the typical peripheral vesicular zone, but in the sections of the earlier part shows continuous septa not reaching the center, with a single zone of dissepiments, while the counter septum extends to the center, and is thickened to form the pseudo-columella. In longitudinal section the abundantly developed tabulae are seen to rise more or less around the columella. It would thus appear that such forms as *Lophophyllum tortuosum* of the Lower Carboniferous show characters which may be regarded as ancestral to *Thysanophyllum* as exemplified by *T. tschernowi* Sochkine of the Permian of Russia.

Carruthers calls attention to the fact that corals of the *Lophophyllum proliferum* type cannot be considered congeneric with *L. tortuosum* and if the latter is to be accepted as the genotype, these others would have to be referred to a new genus. In that case the generic name *Lophophyllidium* (nom. nov.) may be used for them with *L. proliferum* as the genotype. It may, however, be remarked that since corals of the *L. tortuosum* type have been described as *Koninckophyllum*, though the majority of the species figured by Thompson and Nickolson (*loc cit.* Pl. 12) show a more extensive peripheral zone of dissepiments, that it does not seem altogether advisable to apply the law of priority strictly in this case by removing the well-known species from the genus *Lophophyllum* and placing therein the species of *Koninckophyllum*, as suggested by Carruthers. My own opinion would be that less confusion would arise if *Lophophyllum* were to be retained for the species congeneric with *L. proliferum* Mc Chesney or *L. profundum* E & H. and the more specialized Lower Carboniferous species retained in the genus *Koninckophyllum*.

Genus **SINOPHYLLUM** Grabau (gen. nov.)

Usually small, slender conical or horn-shaped corals, straight or slightly curved, with a well-developed epitheca, showing growth-lines, wrinkles, and well-marked septal grooves. Cardinal septum, at least in the typical species on the concave side. Counter quadrants strongly accelerated. In the young, septa grouped in quadri-partite manner, with well developed alar and pseudo-fossulae, and a pali-columella separated off from the counter and perhaps in some cases from the cardinal septum. In later stages, when the septa become more radial, their bent-over ends form a distinct inner wall, either open at both ends or closed on the cardinal side by dissepiments. This wall is often re-enforced by secondary stereoplasm, thickening the ends of the septa and sometimes closing the openings at one side or the other. Central area occupied by the strong pseudo-columella formed by the excessive thickening of the original pali-columella which still remains as the central lamina. In

section, the pseudo-columella shows a zonal or radial structure or an irregular series of rod-shaped bodies. It is always suspended by the more or less thickened counter-septum, giving the section the appearance of a pendulum. The space between this pseudo-columella and the walls is variable but never large. In the adult, the septa become free and shortened, the last to be shortened being the counter septum when the pseudo-columella projects as a more or less conical central mass into the calyx, decreasing apicad, sometimes with the center weathered, giving the appearance of a tube. Cardinal fossula often well developed in the adult. Tertiary septa present, sometimes strong, Dissepiment never numerous.

GENOTYPE: *Sinophyllum* (*Lophophyllum*) *pendulum* Grabau. Distribution, Permian of China.

***Sinophyllum pendulum* Grabau**

Pl. IV, Figs. 1 a-e, 2 a-d, 3 a-c.

1922, *Lophophyllum pendulum* Grabau. This volume, Fascicle 1, p. 48, Pl. I, Fig. 15 a b, 16 a b (not fig. 17 a b which is a *Lophocarinophyllum acanthiseptum* Gr.)

Since this species was first described, a number of specimens have been obtained which permitted serial sectioning. One of these from Loping, (catalogue 1585) has furnished the following sections:

Section	Dorso-ventral diameter	Transverse diameter	Fig. Pl. IV
A	6.4 mm	6.0 mm	1 a
B	8.8 mm	8.8 mm	1 b
C	9.7 mm	9.0 mm	1 c
D	10.5 mm	10.0 mm	1 d
E	12.8 mm	10.5 mm	
		Interval 4.4 mm	1 e

SECTION A. In this section (Plate IV, Fig. 1a) the septa are still united in groups, the cardinal septum is long, and in the direct line of the pseudo-columella which has the appearance of being derived from the cardinal rather than the counter septum. In this section, however, it is already distinct and surrounded by a deposit of stereoplasm which produces an oval mass, the dimensions of which are 1 mm in length and 0.8 mm in width. The counter septum on the other hand passes to one side of the columellar mass, and its end shows a slight additional

thickening. The alar septum on one side (right in the figure) is nearly or quite free, on the other it is joined with the secondary septa of the cardinal quadrants. Of the latter there are 4 in each quadrant, progressively decreasing in size, all joined into a group by their bent-over inner ends. There are 6 secondary septa in each counter quadrant, the 6th short and adhering to the side of the 5th; the others bent at their inner ends to form a section of an inner wall as in the case of the cardinal secondaries. This is, however, not quite complete on one side (left in figure).

There is thus shown in this section the beginning of an inner wall or phyllothea but it is still incomplete. The 4 gaps *i. e.* cardinal, alar pseudo-fossulae and counter, are unbridged. Tertiary septa are indicated.

SECTION B. In this section, the inner wall is more complete by the bridging over of the alar pseudo-fossulae; moreover, the ends of all the septa have become thickened and are in close conjunction, thus changing the character of the inner wall to a certain extent. The tube enclosed by this wall, is almost completely filled by the pseudo-columella, which is strongly thickened, being enlarged by layers of stereoplasm, but in a few places the gap between the wall and the columella is still seen. This wall is only broken where the much thickened counter septum enters the central area, and is fused by its stereoplasm with the stereoplasmic mass of the pseudo-columella. The cardinal septum too, enters the central area, abutting upon the pseudo-columella, but the gaps on either side are filled by stereoplasm or by dissepiments. One or two rows of dissepiments also appear between the other rows of septa. This section also shows an increase in the number of secondary septa, this increase being apparently in the counter quadrants, although from the radial character of the septa, it is not possible to determine the position of the septa with exactitude. But there are 12 septa on either side between the cardinal and the counter, which means that there are 11 secondary septa. In other specimens we find that the number of septa in the cardinal quadrants is 4, which would leave 7 for the counter quadrants.

Tertiary septa present, but do not project beyond the stereoplasm of the wall.

SECTION C. In this section, the conditions are very much as in the preceding except that the cardinal septum has become somewhat shorter and the gap closed by a somewhat oblique bridge which does not touch the cardinal septum. The wall on the whole is more distinct and separated for the most part from the pseudo-columella. The latter is continuous with the strong counter septum, the central portion of which *i. e.* the original septum, is deflected to one side of the center of the pseudo-columella. The stereoplasm of the latter shows a pronounced radial structure. Its diameters are:

longitudinal 2.6 mm; transverse 2.3 mm, length of the median lamella 1.4 mm. Dissepiments and tertiary septa as in the preceding section.

SECTION D. This is remarkable in that it shows the columellar mass, flanked by a pair of lacunæ, which separate the majority of septa from it. These are united by a very stout wall, which near the cardinal septum joins the pseudo-columella, so that the 1st & 2nd pair of secondary septa, together with the counter, are joined in a continuous mass with the pseudo-columella. The cardinal fossula is now distinctly outlined, somewhat flask-shaped, with the rather thin cardinal septum extending about half way its length. Nearly all the septa now have a radial disposition and they are all considerably thickened by stereoplasm, up to 1.2 mm, as is the calicular wall, which is submerged.

SECTION E. This is 4.4 mm higher than the preceding, but only its longitudinal diameter is somewhat increased, due probably to slight compression. All the septa are now radial and free, the pseudo-columella having the true pendulum form, suspended from the counter septum. Its diameters are 3.2 and 2.5 mm respectively in length and breadth. There is a free space surrounding it, essentially commensurate in thickness with the stereoplasmic wall of the sections. The cardinal septum is less than half the width of the others, while the alar and counter laterals are somewhat shorter than they. Tertiary septa appear between the others in practically all the interspaces but the dissepiments are not shown.

Another specimen of this species (Cat. 1586) is shown in Fig. 2 a-d. The cardinal septum is on the concave side and the position of the other septa is well shown in the costal grooves which are broad and separated by sharp narrow ridges, which are cancellated by growth-lines and at the same time rendered slightly nodose by concentric wrinkles. The number of secondary septa in the cardinal quadrants is 4 and in the counter 7. The following sections have been prepared.

Section	Dorsal-ventral Diameter	Transverse Diameter	Interval	Fig. Pl. IV
a	5.7 mm	5.7	} 10 mm } 1. mm } 4.8 mm	not figured
b	10.5 mm	10.5		Fig. 2 b.
c	10.8 mm	10.5		Fig. 2 c.
d	11.8 mm	11.2		Fig. 2 d.
e	12.2 mm	11.7	} 4.8 to 3 mm	—
f	12.7 mm	11.7		—

The earliest section obtained shows a large empty space, an original imperfection in the young coral, probably due to some parasitic growth. This makes the determination of the septa impossible except that their number in the cardinal quadrants seems to be 3 and in the counter 4, the septa apparently meeting in the center. But whether a columella has developed at this stage cannot be ascertained because of the above mentioned imperfection.

SECTION B. This shows the septa essentially radial, proceeding from a thickened calicinal wall, which reaches 1.5 mm. The cardinal septum is slender, somewhat shorter than the others. The alar too, are somewhat shorter than the others but nearly if not quite of uniform length. The counter secondaries are all united into a distinct wall on either side of the counter septum, this being reinforced by stereoplasmic thickening of the ends of the septa. Moreover, this wall is joined on either side by a dissepimental bridge to the counter septum or the pseudo-columella. The secondaries of the cardinal quadrants on the other hand are essentially distinct, quite separate on the right, but touching on the left. There is a complete lacuna or moat between the septal wall and the pseudo-columella, reaching a maximum width of 0.7 mm and bridged only at the counter ends, by the afore mentioned dissepiments, and by a thin projection on the wall from one side. The pseudo-columella is distinctly penduli-form, with diameters of 2.4 and 2.5 mm respectively, suspended from the thickened counter-septum. The median portion is oval and directly and normally continuous with the median line of the counter septum. Tertiary septa project very slightly beyond the calicinal wall.

SECTION C. In this the septa have become free and radial with a broad open space between their ends and the pseudo-columella, though occasionally a septum is prolonged sufficiently to extend across this so as to nearly or quite touch the penduliform pseudo-columella. The latter has diameters of 3.0 & 2.5 mm respectively. The median portion is still oval, but its connection with the median line of the counter septum is no longer recognizable. The cardinal septum is now only about half the length of the others while the alar and counter laterals are slightly longer than the cardinal, but still shorter than the other secondaries. The counter is still much thickened and continuous with the pseudo-columella, No dissepiments are shown and tertiary septa only project very slightly beyond the calicinal rim.

SECTION D. In this section the pseudo-columella has become entirely free and reduced to longitudinal and transverse diameters of 2 and 1.4 mm respectively. The septa which are all radial and free, now project scarcely half way to the center leaving a broad space surrounding the pseudo-columella. Occasionally, however, one is somewhat longer. The cardinal septum is the shortest and the counter laterals are some-

what shorter than the others. The counter septum is still thick at the point of emergence from the wall, but tapers to a point, its length equal to or slightly less than the average secondary. Tertiary septa now well marked but no dissepiments are shown.

SECTION E. In this the two dimensions of the pseudo-columella have been reduced to 1.2 mm and 0.8 mm. respectively. The septa are all somewhat shorter, but in the same proportion, while the tertiary are somewhat more pronounced. The calyx is filled with matrix.

In a third specimen (Pl. IV, Fig. 3.) the calyx is imperfectly preserved, more or less compressed but showing the pseudo-columella as a projecting conical mass, decreasing from a basal diameter of 2.2 mm to a terminal one of 1 mm with a length of 2.7 mm. The summit appears excavated into a hollow tube, due probably to the weathering of the central mass of the columella. This tube has a diameter of 0.7 mm and gives the calyx the appearance of a *Permia*, for which genus it might be mistaken. The depth of the calyx is somewhat over 5 mm with the sides rather steep and marked by the septa.

A section between 9 & 10 mm below the calyx rim, is illustrated in Fig. 3c. It has a dorso-ventral diameter of 8.6 mm, a transverse diameter of 8.7 while the calicular wall has a maximum thickness of 1.2 mm. The pseudo-columella is penduli-form, its two dimensions being 3 & 2.2 mm respectively. The septa are all radial and join in a wall, re-enforced by stereoplasm which is closely applied to the pseudo-columella. The counter septum is thickest and supports the columellar mass which has a radial structure except the central area which appears massive. The median line of the counter septum is deflected to one side within the columellar mass. The cardinal septum, however, which itself is short and triangular is faced by a delicate septal point, projecting from the base of the columella and showing a suggestion of continuance with its center as if the cardinal septum was the original one from which this pseudo-columella was separated. As yet, however, no positive evidence has been obtained from any of our sections that such is the origin of the pseudo-columella though one or two suggest it. The 1st pair of counter laterals is longer than the others and projects beyond the septal wall to the columellar mass itself. Tertiary septa are well indicated in the calicular wall, but do not project beyond it. There are no dissepiments.

HORIZON AND LOCALITY: The forms here described were all obtained from the Mid-Permian Coal Series *i. e.* the Loping Formation of Loping Kiangsi Province. The holotype described and figured in fascicle I, is now believed to have come from

the same horizon at Fengcheng in Kiangsi Province, associated with *Tachylasma elongata* and *Productus graciosus* etc. The form figured in Pl. I, in that memoir as Fig. 17, as a paratype, does not, however, belong to that species, as was shown when the specimen was sectioned. It appears to be a *Lophocarinophyllum acanthiseptum* which led to the erroneous statement that carinæ were occasionally present in *L. pendulum*.

Sinophyllum multiseptum Grabau (sp. nov.)

Pl. V, Fig. 7.

A number of specimens imbedded in a rock and so represented only by sections, show characters sufficiently distinct to indicate the existence of a second species of *Sinophyllum*. In specimen 1608 the section figured on Pl. V, Fig. 7 has a dorso-ventral diameter of 8.4 mm and a transverse diameter of 7.2 mm. The total length of the pendulum is 5.4 mm and the diameters of the swollen part 2.5 and 1.7 mm respectively. The counter septum is less thickened than in the other species, while the structure of the swollen mass presents a series of coarse variously disposed lamellæ resembling the lath-shaped crystals of feldspar in a diabase. The cardinal septum is long and slender and terminally joins the secondaries, besides being tied to them by dissepiments. All the septa form a more or less continuous inner wall, partly through juncture of their bent ends and partly through stereoplasmic thickening. Sometimes, however, this wall is not quite closed, the septal ends not extending fully across. The space between it and the pseudo-columella is very narrow but widens dorsally, where it is open on either side of the counter septum, being continuous with the counter secondaries. Alar septa not differentiated from the others, tertiary septa well-developed, sometimes half as long as the others and frequently bent over terminally to adhere to a secondary. They are present in all the intervals. Dissepiments sparingly developed and in some sections not shown at all.

The chief difference between this and the preceding species lies in the strong development of the tertiary septa, which give a decidedly distinct aspect to the coral, filling as they do most of the inter-septal loculi; the complete union of the septal ends, chiefly by their deflected terminal portion; and the relatively slight amount of thickening of the septa. The much less strongly developed counter septum, the long cardinal septum and the slight thickness of the calicular wall which is scarcely re-enforced by stereoplasmic matter, form other distinctive characters. In some sections the swollen part of the columella shows a distinct zonal arrangement.

HORIZON AND LOCALITY: In the Yanghsing Limestone of Lower Permian age at Fuchikou, Yanghsing Hsien, East Hupeh. Associated with *Fusulina* etc. Liu and Hsieh collectors, Cat. 1608 (figured); also in the same lime-stone in Taling Fuchikou, Cat. 1611. Collected Lui and Hsieh.

Genus **ROSSOPHYLLUM** Stuckenberg

1888 Stuckenberg. Anthozoen and Bryozoen des Oberen Mittel Russischen Kohlenkalks p. 46.

Genotype *R. novum* Stuckenberg (*ibid* page 47 pl. I, figs. 17 to 22.)

This genus was instituted for a single species of small coral from the middle Carboniferous of Russia, in which the two alar septa are shortened, producing corresponding fossulae. In the type species there are six secondary septa, in the cardinal quadrants, and seven in the counter. All the latter, except the 1st pair of counter laterals, appear still to be united into a single group, but the septa of the cardinal quadrants form several groups, and still retain something of a pinnate arrangement. The cardinal septum is long, its pseudo-fossula prominent. Tertiary septa seem to be fully developed, projecting for some distance beyond the thickened wall, the palicol-umella is laterally flattened and continuous with the long counter septum. It is said also to be joined to the cardinal septum. Finally, endothecal tissue in the form of dissepiments, is found in the marginal portion of the caliculus where it is frequently involved in the thickening. Pinnate arrangement is strongly shown in the young where the 4 principal septa seem to meet in the center, if we may judge from the section pl. I, fig. 21. It is this shortening of the alar septa that primarily distinguishes this genus from the species generally referred to *Lophophyllum*.

The genotype *R. novum* is a small species with a height of 12 mm and a calicinal diameter of 10 mm and a calicinal depth of 5 mm. The counter quadrants show the usual acceleration of one septum.

CHINESE SPECIES.

Rossophyllum kansuense Grabau (sp. nov.)

Pl. III, Fig. 3 a-c, 4 a, b, 5 and 6 a-c

Corallum small, rapidly expanding, with the calicinal portion sometimes almost explanate. The growth is most rapid on the cardinal side, which in the adult has reached about twice the length of the counter, making the calyx very oblique. Nevertheless, the curvature is not a very apparent one because of the very rapid enlargement. The two best preserved specimens show the following dimensions:

	I	2
Vertical height from plane of calyx	9.0 mm	8.2 mm
Actual length on curvature, cardinal side.	22.5 mm	16.7 mm
Ditto on counter side.	7.0 mm	6.5 mm $\pm$
Diameter of calyx	17.3 mm	15.5 mm
Depth of calyx about	12.0 mm	8.0 mm $\pm$

The epitheca is thin and marked with growth-lines, but is not well preserved. The costal grooves seem to have been only slightly marked but the weathering of the specimen has exposed the ends of the septa, which gives the exterior a strongly rugose appearance. In the calyx, the septa arise as somewhat flexuous lamellæ, still more or less grouped, especially in the cardinal quadrants. The fossula is well marked, showing the aborted cardinal septum which is much lower than the others. In the center of the calyx the pali-columella appears in some of the specimens as a laterally flattened projection, but it is not always well shown because of the complications produced by the septal ends.

SECTION I. (Pl. III, Fig. 6a) This section has a maximum diameter of 8 mm and a minimum of 7.5 being thus slightly oblique. It is seen from below, hence reversed. The counter septum is well marked, reaching to the center, where it is somewhat thickened to form the pseudo-columella. The 1st pair of counter secondaries is slightly shorter than the others. There are in all 4 of these well-marked secondaries in the right, and 5 in the left-hand quadrants (appearing reversed in the section as figured). Then follows a shorter septum on either side which is apparently the alar, though because of the difficulty of orienting the section, owing to the weathered character of the surface, this point cannot be ascertained with certainty. In any case, each shorter septum reaches only about half-way to the center, whereas the others extend more than two-thirds that distance. The cardinal septum is of about the same length as the alar and is flanked on either side by 4 secondary septa, increasing progressively in length towards the alar septum *i. e.*, their relative length corresponds to the order of appearance. All the septa of the cardinal quadrants are thickened in their median portion for some length by stereoplasm, and from the cardinal there extends a delicate line towards the center, which suggests the possible greater length of the cardinal septum than is suggested by the preserved part.

Tertiary septa appear to be absent at this stage and dissepiments are few.

SECTION II. (Not figured). This is about 1.5 mm above the preceding and is seen from above, hence the orientation is normal. It has a maximum diameter of 9.5 mm which is approximately the normal. The counter septum is long and thin, but does not show the thickening of the interior, shown in the preceding section. There is, however, a deposit of stereoplasm at the end of the first two right-hand secondary septa of the cardinal quadrants which might be mistaken for a pseudo-columella. It is flanked by secondary septa, progressively increasing in length outwards, the outer meeting with it in the center. There are 4 of these on the left-hand side, and 5 on the right. Then follow the 2 alar, the right-hand one of which appears to be somewhat longer than the left, although the structure is complicated by the deposition of crystalline calcite. Where typically developed, as on the left-hand side, the alar extends about half-way to the center. There are 5 secondary septa in each counter quadrant progressively decreasing in length, except the 5th, which is only half as long as the 4th and shorter than the cardinal septum which is fairly stout and extends about $\frac{1}{4}$ the distance to the center. There is thus a large open fossula. The septa of the cardinal quadrants are somewhat more thickened than the counter by secondary stereoplasm, but taper regularly inward. They are fairly regular and rigid, while those of the counter quadrants are slightly flexuous toward the center. Dissepiments are sparingly developed.

SECTION III. (Pl. III Fig. 6b). This is some distance above the preceding and seen from below, hence reversed. In this section the cardinal septum is very short and the 5 flanking secondary septa reach only about $\frac{2}{3}$ the way to the center, being nearly of equal length. The alar are slightly shorter and thicker and there appear to be 5 secondary septa in each counter quadrant, indistinguishable, however, from the counter septum. In front of the latter there are two distinct elongate oval masses of white stereoplasm which might be the sections of a more or less irregularly displaced pali-columella, since they do not point directly towards the center. They may however be foreign bodies embedded in the filling of mud. All the septa taper more or less towards the center and a few strong dissepiments are present; otherwise the inter septal loculi are vacant. Tertiary septa are indicated by septal grooves on the epitheca but are scarcely shown inside of it. The diameter of this section is 11.3 mm.

SECTION IV (d) (not figured) This is about 1.5 mm higher. The maximum diameter is 13.5 mm which is probably somewhat greater than the normal, because of obliquity. This is normal, being seen from above. The cardinal septum is but slightly shorter than the others which extend less than half way to the center. There are 23 septa in addition, all of about the same length and with short tertiary septa between all of them. Of these 23, one is the counter which is no longer than the others and indistinguishable from them and 2 are the alars which likewise are scarcely distinguishable from the others. This leaves 20 secondary septa which appear to be equally distributed in the quadrants, which are thus equally accelerated. No columella appears in the center, and dissepiments are confined to the periphery.

SECTION V (e) (Pl. III Fig. 6c) This has a diameter of approximately 16 mm, and still contains about 24 septa in addition to the cardinal. But some of the tertiary

septa have become fairly long, so that they might be mistaken for secondaries. What is apparently the cardinal septum is short and rather thick and flanked on either side by a tertiary septum of about its own length, outside of which is a secondary septum twice as long. In general these septa extend only $\frac{3}{8}$ the way to the center and there is a marginal dissepimental zone about 1.3 to 1.5 mm in thickness, but the rest of the caliculus is free from endothecal structures.

All the sections described are taken from the same individual.

HORIZON AND LOCALITY: In the Middle Carboniferous Moukou Limestone of Moukou, Fu-I-Hsien, Kansu. Collected by P. L. Yuan, Locality 510. Cat. G. S. Ch. 1580, 1581, 1582, 1583.

Genus **TIMORPHYLLUM** Gerth.

Pl. III, Fig. 7a-7b.

Text. Figs 17, 18.

1921 Gerth-Die Anthozoen der Dyas von Timor. Palæontologie von Timor IX, page 72.

Genotype *T. wanneri* Gerth, *ibid* page 70. pl. I, figs. 8-10 text-fig. 1. Var. *variabilis* Gerth, *ibid* page 71 pl. I, fig. 11, 12. text-figs. 2-4. Var. *ajermatiensis* Gerth *ibid*. page 72.

This genus was erected for simple corals which grow to long cylindrical irregularly bending tubes, usually preserved only in fragments. They are each covered by a moderately thick wrinkled epitheca; branching not observed. The calyx is shallow, the septa in the young stage clearly show the arrangement into groups. In the cross-section of variety *variabilis* Gerth (Pl. III Fig 7b) the counter and alar septa unite in the center while the cardinal septum is short. The first pair of secondaries in the counter quadrants, i. e. the counter laterals, join the counter septum some distance above the center, while 3 other septa occur in that quadrant on one side but only two on the other. The cardinal quadrants at this stage have only 2 septa which are pinnately arranged with reference to the shortened cardinal septum. The diameter at this stage is about 10.5 mm. Two cm further, (Plate III Fig 7a) where the diameter has reached 26 mm, the counter septum is free, extending to the center where it is slightly thickened into a pseudo-columella which is, however, not separated from the septum. All the other septa are free and radial. The first pair of counter laterals is no longer than the second. There are now six secondary septa in each counter quadrant, the last being short. The alar septa are longer than any of the others, but at that, reach

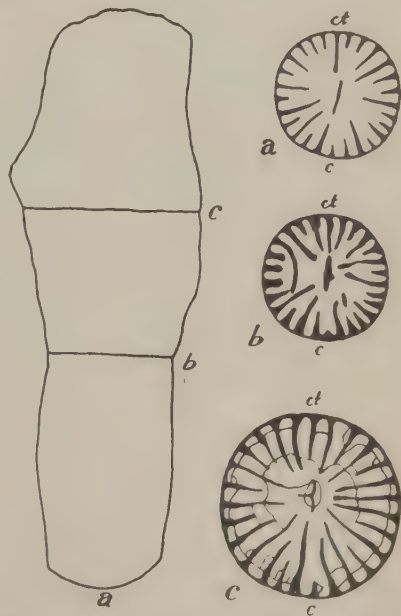


Fig. 17 *Timorphyllum wanneri* Gerth var *variabilis* Gerth. A fragment of a corallum with three cross-sections at the points indicated by the lettering a, b, c. Permian of Basleo Timor. (After Gerth).

scarcely $2/3$ the way to the center. Beyond them are 3 secondary septa in each cardinal quadrant, progressively decreasing in length toward the cardinal septum which is the shortest of all.

In another specimen of the same variety (Text Fig 17) section (a) 13 mm in diameter shows the pali-columella separated from the counter septum and narrowly compressed, but much elongated. The septa are all thin, but in section (b) about 24 mm higher, and still of the same diameter, both the pali-columella and the septa have become thickened. In length the septa are irregularly developed, several of them standing out rather prominently, but these are not the counter laterals nor the alar, but appear to be early secondary septa. 14 mm higher, (sect. c) the diameter is 19 mm and there are 27 septa in all including the short cardinal. Many of them are lengthened but there appears to be no regularity in this respect.

In the typical species, *T. wanneri* Gerth, the corallum rapidly enlarges from a horn-shaped young, to cylindrical form which sometimes reaches a diameter of 2 c m and frequently shows constrictions.

The epitheca is thick, showing only growth-lines and wrinkles but no septal grooves. In the young, the calyx is rather deep around the pseudo-columella but in the adult becomes shallower. The septa are short, thick and do not reach the center, which is formed only by upward arching tabulae through which projects the laterally compressed pseudo-columella, like a sharp median crest. (Text Fig 18) Occasionally this pseudo-columella is still continuous with the counter-septum from which it is derived, constituting a pali-columella, the cardinal septum opposite is aborted, to form a pronounced fossula, which to a certain extent partakes of the nature of a siphono-fossula from the slight depression of the tabulae. Sometimes the secondary septa become very long, so as to exceed even the tertiaries which would make the determination of the succession a difficult one. The total number ranges from 26 to 30. The septa and columella are occasionally thickened, but not to the same degree as that seen in the variety *variabilis*. The most characteristic features of the genus, however, are the sub-regular tabulae which are depressed marginally, and again in the median portion, but show rather steep upward arching around the columella.



Fig. 18 *Timorphyllum wanneri* Gerth longitudinal median section of a fragment showing the pseudo-columella c, the septa s, and the tabulae. $\times 7/5$ natural size, Permian of Easleo Timor. (After Gerth).

Family **LINDSTROEMIIDAE** Pocta (Emend. Grabau)

Pocta included in his family the genus *Lindströmia* together with the genera *Nicholsonia* (*Alleynia*) and *Barrandeophyllum* which have, however, a very different structure, their so-called pseudo-columella, being in reality an inner wall surrounding a tabulated tube, whereas the pseudo-columella of *Lindströmia* is typically of the nature of a stereo-columella. There is, however, another genus *Kionelasma* Simpson which belongs here.

Genus **LINDSTROEMIA** Nicholson & Thomson

1875 Nicholson H.A. & Thomson, Proceedings Royal Society Edinburgh, Vol. IX, No. 95, page 149.

In Nicholson and Etheridge Jun. (Silurian fossils of the Girvan district, part 1 p. 80) they give the following definition. (See Text. figures 19a-c)

“Corallum simple, conical or turbinate, the epitheca complete, with well-marked longitudinal ridges, fine encircling striae and low annulations of growth. Septa well-developed, lamellar, equally developed or of two sizes, united inferiorly in the axis of the visceral chamber and augmented by a secondary deposit of sclerenchyma so as to form a comparatively enormous pseudo-columella which projects into the floor of the calice. The lower portion of the visceral chamber often more or less completely filled up by the deposition within it of solid sclerenchyma. Inter-septal loculi usually crossed by a few strong and remote dissepiments and the upper portion of the visceral chamber not uncommonly traversed by thick transverse plates of the nature of tabulae, though at other times these are not recognizable or at any rate have not been clearly made out.”



Fig. 19 a Vertical section of *Lindströmia dalmani* (F. & H.) enlarged $\times 2$, showing dense infilling of lower part of coral, the large pseudocolumella, and the tabuloid dissepiments. a' Transverse section of the same enlarged $\times 3$, showing dense central mass and almost complete amalgamation of septa by sclerenchyma. b. Vertical section of *Lindströmia columnaris* Nich. and Thoms. enlarged $\times 3$, showing filled-up base; the partially amalgamated vertical rods which compose the pseudocolumella and the imperfect tabuloid dissepiments. b' Transverse section of the same enlarged $\times 3$, showing fusion of septal ends by means of secondary sclerenchymatous deposit (stereoplasm) into the pseudocolumella. c Vertical section of *Lindströmia subduplicata* (Mc' Coy) enlarged $\times 2$, showing central fasciculate pseudocolumella, deep calyx, and imperfect tabuloid dissepiments. c' Cross-section of the same, close to the base, enlarged $\times 5$, showing almost complete fusion of septa by secondary deposit. (after Nicholson and Etheridge jun. 1878.)

The genus was originally made for the reception of small Devonian corals from North America, which apparently have never been described, but in the monograph on the fossils of the Girvan district, Nicholson and Etheridge describe an Ordovician and a Silurian species, which really must be taken as the types of the genus. The first of these is the *Petraia subduplicata* of McCoy, (Text.-Fig. 19 c, c') which is cited as both from the Ordovician and the Llandovery horizon. This is a small conical, straight or slightly curved corallum of *Petraia*-like aspect with the epitheca showing the septal grooves and pinnate arrangement. The calyx is moderately deep and marked upon the inside by the septal ridges which in the floor of the calyx meet the very solid stereo-columella. This columella fills the entire lower part of the corallum, where the united septa are also thickened until the entire basal portion of the corallum is nearly solid. The stereo-columella projects strongly into the calyx and appears to be made up of a series of vertical rods more or less uniting into a solid mass. This columella, as shown by the combination of numerous sections, "is really to be regarded as formed by the fusion of the inner ends of the whole or a number of the septa, together with a larger or smaller amount of dense calcareous tissue, which is clearly of secondary and non-essential origin, since it often invades the interseptal loculi and may entirely fill up the lower part of the visceral chamber. The upper surface of this pseudo-columella may be quite smooth and sharply defined (as in *Lindströmia dalmani* E. and H.) or it may exhibit its real structure by presenting itself in the floor of the calice as a bundle of partially fused lamellæ. In any case, longitudinal sections of the corallum show that it is really formed in the manner above described, namely, by the amalgamation of the inner ends of a larger or smaller number of the septa, this amalgamation taking place without any twisting of the septa and being accompanied by a more or less copious secondary deposition of sclerenchyma", (loc. cit. pages 82-83.)

The longitudinal section given by Nicholson & Etheridge shows this columella relatively thin and solid in *L. dalmani* E. & H. (*Cyathaxonia dalmani* E. & H.) (Text-Fig 19a, a'). In *L. subduplicata* (Text-Fig 19 c, c') it is much thicker and composed of a bundle of rods only partially separated and then very slightly. In *L. columnaris* Nicholson & Thomson (Text-Fig 19 b, b') on the other hand, where the base of the corallum is solidly filled, the columella is composed of only partly conjoined rods, their separation being sometimes equal to their thickness or more, when they are united by imperfect tabula-like plates.

Dissepiments are only sparingly developed, but may be absent entirely. When they occur they have more or less the form of tabulæ in longitudinal section.

The septa of *L. subduplicata*, of which there are from 50 to 60 in all, appear to comprise an equal number of longer and shorter, the latter representing the

tertiaries. But, up to the present, no distinction seems to have been made between the primaries and the secondaries, and it is impossible to discover which of the quadrants, if any, are accelerated. A fossula is absent.

In *L. laevis* Nicholson and Etheridge, the number of longer septa ranges from 15 to 23. In a young section, with a diameter of about 4 mm, the cardinal septum seems to be shortest, the two septa flanking it joining the median columella. Opposite it are two septa which unite before joining the columella and if these represent the counter laterals, the counter itself is also shortened. The total number between the assumed cardinal and the assumed counter laterals is 5 long septa on either side, though on one side one of these has an additional lateral septum joining it. All the septa join the columella.

Another section just below the calyx from another specimen, with a maximum diameter of slightly over 6 mm, shows the septa free from the columella, which becomes more or less compressed, but from the appearance of the septa, it is not possible to determine the primary or the secondary. If the two large lateral septa are the alar ones, then it would appear that the quadrants are about equally accelerated. Nicholson & Etheridge state that tertiary septa (their secondary) are probably present, but not determined with certainty. Dissepiments are stated to be unknown, but the few remote and strongly arched and ascending plates, which intersect the visceral chamber near the base, and take part in the formation of the pseudo-columella, and which have been referred to as tabulae, are probably more of a dissepimental character. This species occurs in the lower part of the Silurian series. *L. dalmani* (E. & H.) is likewise a Silurian species.

This peculiar form of the pseudocolumella, composed as it is of the inner ends of septa or pali united by stereoplasm, separates this type from all those hitherto known, and suggests the possibility that it may be ancestral to some of the more complex types of syncolumella, such as are found in *Dibunophyllum* etc.

Genus **KIONELASMA** Simpson

1900 Simpson G.B.—Preliminary description of new genera of Rugose corals p. 207

This genus was erected for the coral previously known as *Streptelasma mammi-ferum* Hall of the Onondaga (Middle Devonian) Limestone of the Falls of the Ohio (Text-Fig 20a-b). In it he also includes the *Cyathaxonia gainesi* Davis from the same horizon and locality, and *Streptelasma spongaxis* Rominger from the Michigan Middle Devonian, and *Cyathaxonia herzeri* Hall 1882 of the Niagara group (Text Fig 20 c). The generic description is as follows. (Simpson, *loc. cit.*)

"Corallum variable in size, cylindrico-conical or horn-shaped. Calyx circular or elliptic, septa alternating in size. The larger ones continuing to, or nearly to, the center, where they become thickened and some of them much involved or twisted, forming a central spongy axis or pseudo-columella which becomes consolidated and projects prominently from the bottom of the calyx. Tabulæ and dissepiments present but comparatively infrequent."

"This genus resembles *Cyathaxonia*, *Lophophyllum*, *Axophyllum* and others in having a strong projection from the bottom of the calyx, but internally it differs from all of them."

Simpson compares his genus with *Lindströmia* to the sections of which it has a close resemblance, but he does not find evidence in his genus of the paligenous origin of the pseudo-columella. He considers that the twisting of the septa is one of the most pronounced characteristics of *Kionelasma*.



Fig 20 a *Kionelasma mammiferum* (Hall). Transverse section showing disposition of septa and character of pseudo-columella. b *Ibid.* Longitudinal section showing pseudo-columella, and tabuloid dissepiments. Onondaga limestone (Mid Devonian) Falls of the Ohio; c. *Kionelasma herzeri* (Hall). Longitudinal section showing the pseudo-columella and subcystose tabuloid dissepiments. Niagaran group. (after Simpson)

Simpson cites *Streptelasma spongaxis* Rominger (Fossil Corals, page 144 pl. 39, fig. 2) as another example of his genus. These are Streptelasmoid forms of conical habitat with a moderately deep calyx from the center of which rises a strong spongy pseudo-columella, forming a dome-shaped elevation. There are about 30 septa which mark the side of the calyx, alternating with an equal number of shorter ones. The longer ones (primary and secondary) join the pseudo-columella. The surface of the septa is "decorated with granules and transverse rugæ". The fossula is obscure.

The average size of the specimens from the Niagaran of Point Detour Michigan, and Drummond's Island, is about 2 cm in diameter by 3 in length. Much larger specimens from Indiana and the Falls of the Ohio have a similar large axial mass, but from the center of this projects a compressed cristiform structure, suggesting the pali-columella of *Lophophyllum* etc. These may possibly represent a distinct type.

Another form cited by Simpson as belonging to his genus was figured by Davis, under the name *Cyathaxonia gainesi* Davis (Kentucky Fossil Corals, pl. 104, figs. 1-6) from the lowest strata of the Niagaran group near Louisville Ky. (Falls of the Ohio). These were however never described. The corallum is short and curved, with the costal grooves well marked, the cardinal on the curved surface showing the pinnate arrangement. In the center of the calyx rises a rather small compressed pseudo-columella of the *Lophophyllum* type, apparently surrounded by a spongy mass, but this is not clear from the photograph. This may, however, be the form referred to by Rominger, and of which he figures a large specimen from the same general region.

Neither of these American specimens has been sectioned and it is therefore impossible to determine their precise characters, nor their relationship either to the type species of *Kionelasma* or to *Lindströmia*.

Simpson figures a longitudinal section of another species, described originally as *Cyathaxonia herzeri* by Hall from the Niagara group. (Text-Fig 20 c). This is a broadly horn-shaped coral with a large median pseudo-columella projecting boss-like from the calyx and joined by the longer septa. In longitudinal section this appears like a solid mass of stereoplasm, against which the tabuloid dissepiments and cystosepiments rise, but no detail of structure is shown in this section. Both in this and the type species the epithecal wall is greatly thickened on the inside by stereoplasm.

To a moderate extent these longitudinal sections recall those of *Stereolasma rectum* and *S. ungula* (Hall), which also show a solid deposit of stereoplasm in the center, but this does not form a marked columella, nor does it appear in the calyx to modify the septa. It appears to be rather a secondary deposit in the older part of the corallum, though it is possible that the early stage in a measure repeats the character of the adult of *Kionelasma*.

Family **CYATHAXONIDAE** E. & H. (Emend. Grabau)

(See Fascicle I page 67.)

The following note regarding the presence of tabulae in *Cyathaxonia* may be quoted from Carruthers (*loc. cit.* p. 54).

"Apparently it has always been supposed that this beautiful little coral had no tabulæ, being open from top to bottom. Chiefly on this ground the genus has been placed in a family apart from other Palæozoic corals (The Cyathaxonidæ of Milne Edwards & Haime), which has supplied material for much ingenious speculation as to possible descendants amongst the Hexacoralla. As a matter of fact, tabulæ are present in abundance. They are, however, very thin, and doubtless the misconception arose because these little fossils, as found at Tournai, are invariably silicified, and so fragile that tabulæ are not apparent on breaking open a specimen. But if the coral be first steeped in hot Canada balsam, and then carefully ground down, a thin section can be made, in which the tabulæ are clearly seen, rising upwards to the strong central columella. When the specimens are calcareous, as are most of those from British and Irish localities, vertical sections showing tabulæ are readily obtained, although microscopical examination is generally requisite, owing to the very small size of this species".

In the description of the family on page 67 (Fascicle 1) the statement that the interseptal loculi are empty without dissepiments or tabulæ is made, a statement which also appears in the diagnosis of the family in the latest edition of Zittel. It seems that Carruther's paper has generally been overlooked and these misconceptions will now have to be corrected. But it is a mistake to assume, as Carruthers does, that the family is primarily based upon this fact, for in itself that is of comparatively little significance. It is, however, in the character of the columella that an important difference lies. It does not appear in the beginning it is true, but after a certain number of the septa have appeared, and then begins as a median thickening of the septal ends, after which, as Carruthers has shown, it continues independently of the ends of the septa. According to Carruthers:

"Thin transverse sections show the calcite fibers radiating outwards from a central point, usually dark; concentric coloured growth-rings are usually to be seen around this axis. The major septa are fused against the columella, but in no way partake in its construction, for their crystalline fibers and central dark or white line terminate as soon as the columella is reached.

"Vertical sections also demonstrate the independence of the columella and septa. Here again the arrangement of the crystalline fibers (at right angles to which growth takes place) indicates the absolute lack of continuity between septa and columella, although these latter are in complete contact" (page 54).

The order of appearance of the septa was shown by Fourot, and is given on pages 68 & 69 of the preceding memoir, furthermore demonstrating the distinctness of this family from those of the other types so far studied in detail. This feature then, as well as the

peculiarity of the columella, are sufficient to distinguish the family of Cyathaxonidæ from all others but it demands the removal of both *Petraia* and *Polycoelia* from this family, as has been done in the present memoir. So far as now understood the CYATHAXONIDÆ represent a distinct morphological modification which is quite unique.

Genus **CYATHAXONIA** Michelin

1922. This Volume; Fascicle I, pp 68; 69.

1895. Stuckenberg—Mem. Comit. Geol. Vol. X, p. 185, pl. I, fig. 3a c, 4, pl. III, fig. 1.

Stuckenberg lists 2 species of *Cyathaxonia* from the Upper Palæozoic Limestones of the Ural region. One he refers to the type species *C. cornu* Michelin and the other he described as a new species *C. krotowi*. *C. krotowi* is a slender curved or geniculated species, which may reach a length of 15 to 25 mm and a calicinal diameter of 9 to 10 mm, though the majority of individuals rarely exceed 5 to 6 mm in diameter with a proportional length. The calyx is deep, reaching 5 mm where the length is 15 and its floor is marked by a solid round columella, pointed at the upper end, and 1 mm in basal diameter. There are 35 principal septa only, the cardinal being distinguishable among the 4 primary, this being shortened with the formation of a small fossula; 17 of the septa reach the columella. Where the stronger growth-lines cross the ridges defined by the septal furrows, small blunt nodulations are produced. The species is widely distributed in the lower as well as the upper division of the Carboniferous system of the Urals.

Genus **CYATHAXONELLA** Stuckenberg.

1895. Stuckenberg. loc. cit. p. 186, pl. V, fig 6, pl. VI, fig. 5, pl. VII, fig. 4.

GENOTYPE: *Cyathaxonella gracilis* Stuckenberg.

This genus was erected for a coral from the Lower Carboniferous Limestone of the Western Urals, which differs from *Cyathaxonia* in the character of the columella. This is composed of radially placed and slightly twisted lamellæ. The type species reaches a length of 40 mm and the round calyx has a diameter of 8 mm. Septal grooves as well as irregular annulations mark the epitheca, which is moderately thickened within. The calyx has a depth of 12 mm. The principal septa are 28 in number, the cardinal septum being shortened to form a fossula. The others reach the columella. Tertiary septa present in all inter-spaces, not more than half the length of the principal ones. The columella is of ellipsoidal section with basal diameters of 3 and 4 mm respectively. It is bluntly rounded on top and marked on the sides by the spirally

ascending edges of the lamellæ which compose it. Neither tabulæ or other endothecal structures are present.

Lacking the study of the serial development of this species, it is of course impossible to determine its relationship to *Cyathaxonia* proper. The lamellose character of the columella suggests rather a distinct origin and it is not impossible that this species represents a parallel development to *Cyathaxonia cornu* in another phyletic series. Judging by its external form of course, it would seem to be a member of the family CYATHAXONIDÆ as here limited.

Family **HAPSIPHYLLIDÆ** Grabau (Fam. nov.)

Simple corals, usually of small size, and of conical or horn-shaped form, straight or curved. Epitheca with growth lines, often with wrinkles and with the septal grooves generally well-marked. In some forms the surface is covered with strong hollow spines. Counter quadrants accelerated, often strongly so, containing in extreme cases four times as many secondaries as the cardinal quadrants. Counter septa united by their inner ends to form a secondary wall or phyllo-theca, which may also include the alars and secondaries of the cardinal quadrants. The wall may be incomplete, open on the cardinal side with the cardinal septum projecting into the gap or shortened to form a cardinal fossula; or it may be closed by a dissepimental bridge across the cardinal gap. The wall may be modified by the thickening of the ends of the septa, or by the development of a median mass of stereoplasm more or less crescentic in transverse section. Tertiary septa indicated or moderately developed. Tabulæ when present, restricted to the inner area; dissepiments present in most cases but not abundant.

The Genera now included are:

<i>Hapsiphyllum</i> Simpson	Dinantian to Permian
<i>Allotropiophyllum</i> Grabau	Carboniferous
<i>Meniscophyllum</i> Simpson	Dinantian to Carb.

Genus **HAPSIPHYLLUM** Simpson

1900. Simpson: New Genera of Palæozoic Rugose Corals Bull. N. Y. State Museum, No. 39, p. 203.

SIMPSON'S ORIGINAL DESCRIPTION:

"Corallum small, simple, conical or horn-shaped; calyx circular, comparatively deep, with thin margins; bi-areal. The outer area is bounded by the external epitheca; the inner area by a sub-vertical wall of horse-shoe shape, open on the side of the septal

fovea. Two of the larger septa connect with this wall in such a manner as to be apparently a continuation of it, and form a very distinct pyriform septal fovea; Septa alternating in size, the smaller ones continuing for a short distance into the cavity of the corallum, there coalescing with the larger ones, which continue to the inner wall, with which they coalesce and in which they terminate. Tabulæ and dissepiments are present.

"The wall of the inner area, connecting with two of the septa and bounding a portion of the septal fovea is similar to that of *Agonophyllum* but that genus differs from this in several respects, principally in having carination on the sides of the septa".

GENOTYPE: *Zaphrentis calcariformis* Hall. St. Louis group. Washington County. Indiana.

This is one of the types of zaphrentiform corals, so widely represented in Carboniferous rocks in both Europe and America. Among European representatives *Zaphrentis delanouei* E. & H. may be considered a typical example, while *Z. konincki* E. & H. may also be placed in it, despite the large number of septa which differentiates it from the other forms. *Z. omaliusi* E. & H., however, probably represents a distinct generic group. Most of the species figured by de Koninck on Plate X of his "Nouvelle Recherches" belong here. All these forms are characterized by having the counter quadrants accelerated, and the septa united into a horse-shoe shaped inner wall, by the septal ends themselves. This wall is of the type found in the *Laccophyllidæ* and in *Craspedophyllum* and is an incomplete phyllothea.

In the genotype, *H. calcariforme* (Text-Fig. 21) there are 13 septa between the cardinal and counter on each side, making 12 secondaries but their distribution in the quadrants is not determined. The probabilities however, judging from analogy with the other species is that there are four in the cardinal and 8 in the counter. The tertiary septa all adhere to the secondaries in the type species, the counter septum having one on each side, which is longer than that found in other septa. In the European species however the tertiary septa are most usually free and often only very slightly developed. The cardinal septum in the type species is very short, but in the European and Asiatic species it is often long.

The great acceleration of the counter quadrants, allies this genus more closely with the STREPTELASMAIDÆ than with the ZAPHRENTIDÆ. Indeed, almost the



Fig 21 *Hapsiphyllum calcariforme* (Hall.) Transverse section showing the key-hole shaped wall enclosing the center and the septal gap: The tertiary septa join the secondaries and the primaries, the short cardinal excepted. St. Louis Group Washington Co., Indiana. (After Simpson)

only important feature which it has in common with typical *Zaphrentis* is the possession of a fossula, but even this is of a very different character in the present group. In typical *Zaphrentis* no such inner wall is ever developed, the septa becoming radial except in primitive forms.

This genus seems to be fairly well represented in the Carboniferous rocks of China, especially in the Dinantian.

CHINESE SPECIES.

Hapsiphyllum yuani Grabau. (sp. nov.)

Pl. IV, Figs. 5 a to f.

Corallum of average size for the genus, but more rapidly expanding than most of the species, reaching a diameter of 13.5 mm in a length of 15.5 mm, gently curved with the cardinal septum on the flatter or concave side. Exterior marked by lines of growth and occasional wrinkles and with the costal grooves linear but sharply marked, the intervening ridges being elevated and rounded. Both cardinal and counter septa well-marked, but the alars of the same characters as the secondaries. Their position however is determinable from the septal grooves where it appears that the cardinal quadrants have 4 and the counter quadrants have 6 septa with a 5th appearing in the cardinal quadrants in the adult. The full depth of the calyx is not preserved in the type specimen, but seems to have been rather pronounced, with the septa becoming free upon its margin.

A series of sections of the type specimen show the following dimensions.

Section	Dorsal ventral	Transverse	Interval	Pl. IV
a	3.6 mm	3.9 mm	} 2.5	—
b	5.0 mm	4.7 mm		5 b
c	6.8 mm	5.6 mm	} 2.5-3.7	5 c
d	8.3 mm	7.8 mm		5 d
e	10.1 mm	9.9 mm	} 4.2	5 e
f	11.7 mm	11.7 mm		5 f

SECTION B. (Pl. IV, Fig. 5 b). The cardinal septum is thin and slender, extending quite to the central stereoplasmic area, bounded by the last pair of secondary septa

which meet in the central stereoplastic mass. The counter septum is strong, being the thickest of the series and like all the others joining the central stereoplastic mass which is formed by the thick inner ends of all the septa except the cardinal. At this stage there are 3 secondary septa in the cardinal quadrants and 4 in the counter. The alar have the same character as the secondary septa, and join the 3 secondaries to form a group. The alar pseudo-fossulae are rather strong. The four secondary septa in the counter quadrants are also much thickened so that the interseptal loculi are reduced to tear-drop form. On the left there is an incipient 5th secondary which joins the 4th. The calicular wall is only slightly thickened. Tertiary septa are indicated by the costal grooves, but do not project beyond the wall.

SECTION C. (Pl. IV, Fig. 5 c). In this a 4th cardinal secondary has appeared, joining the preceding ones, while the center of the stereoplastic mass has opened on one side of the cardinal septum, but on the other this still adheres to the stereoplastic mass. The septa are proportionately less strongly thickened and there are now 6 septa on the left side in the counter quadrants (right in the figure which is reversed) and 5 on the right (left in the figure) the last one being still incomplete and adhering to the preceding one. The counter, and several of the adjoining secondaries are still much thickened, but on the whole the stereoplastic thickening has been much reduced. There is a slight spiral arrangement of the septal ends in the interior region and the junction of the septa is well shown by the median septal line. No tertiary septa are seen, though the costal grooves for them are strongly marked.

SECTION D. (Pl. IV, Fig. 5 d). In this the stereoplastic central mass is further diminished, being chiefly formed by the thickened ends of the septa, with only a slight addition both within and without. The septa join, all those on the right side, including the alar and cardinal secondaries, curve towards the counter septum, the same being true of the counter secondaries on the left. The alar and the 4 cardinal secondaries on the left, however, form a distinct group in which the septa are essentially radial and unite by their thickened ends. This destroys the symmetry of the inner walled region, which is divided by the projecting inner part of this left-hand group of septa. The cardinal septum reaches about half-way to the center. The counter is somewhat more strongly developed than the others, but the alar are of the same character as the secondaries and their position can only be determined from the costal grooves. The 6 secondary septa of the counter quadrants are now fully developed; though the space between the last two is still somewhat narrower than that between the others. The cardinal quadrants have 4 septa each. Tertiary septa only indicated by the costal grooves. No dissepiments.

SECTION E. (Pl. IV, Fig. 5 e). In this the stereoplastic mass is still further reduced, forming only a narrow ring around the inner area. The counter septum is still thicker and its end is bulbous, resembling an electric-light bulb. The secondary septa of the counter quadrants are similarly thickened, though to a lesser degree. The alar and 4 cardinal secondaries of the left side (right in the figure which is reversed), are now entirely free from stereoplasma and are no longer united but project freely into the central cavity, their ends only slightly thickened. On the right, however, (left in the figure) the cardinal secondaries and the alar are still united with the others, completing that side of the horse-shoe-shaped inner wall. The cardinal septum is somewhat shorter, slender and pointed. Tertiary septa not yet shown in the interior or only occasionally so. A slight amount of dissepimental tissue is seen in the periphery, in a few places.

SECTION F. (Pl. IV Fig. 5 f.). This is through the calyx and the septa are now all free and radial, slender, not thickened, and projecting little more than $1/3$ the distance to the center. The counter septum is slightly longer than those adjoining it, but scarcely thickened. The cardinal is slightly shorter than the others and there now has appeared a 5th septum in the right cardinal quadrant, next to the cardinal, and somewhat longer than it. The corresponding one in the left-hand quadrant is still short. Tertiary septa only partially developed on the inside though fully marked by the costal grooves. No dissepiments, although the periphery of the left-hand quadrants shows a slight amount of stereoplastic matter.

It appears in so far as the internal structure of this species is concerned, that it is essentially free from dissepiments or tabulae, the only endo-theal structure being the stereoplastic material in the center. The counter quadrants are accelerated, containing normally 2 more septa than the cardinal. These features and the general form distinguish it from *Hapsiphyllum delanoui* E. & H. which is its nearest relative, and to the group of which it belongs. That form as figured by Carruthers (1908 pl. V fig. 6) has 7 secondary septa in the counter quadrants and 4 in the cardinal. Dissepiments are rather marked and the cardinal pseudo-fossulae are bridged by strong dissepiments, though the alar and most of the cardinal secondaries become free in the last stage, where however, the septa of the counter quadrants are still united.

Z. delanoui forms a distinct horizon in the Middle Tournaisian of the West European Dinantian and belongs therefore apparently to a lower horizon than the Chinese species. Sections of another specimen of *Z. delanoui* from the cement stone group of Liddesdale Scotland (Lowest division of the Calciferous Sandstone series of the lower Carboniferous, immediately above the Old Red Sandstone) shows simpler characters, there being only 3 secondaries in the cardinal quadrants and 6 in the counter. Other related species of this group are *H. parallela* (Carruthers) *H. constricta* (Carruthers),

and *H. disjuncta* (Carruthers); the first from the cement group, the others from the Lower members of the Carboniferous limestone overlying it. All of these show only 3 secondaries in the cardinal quadrants and 5 or 6 in the counter.

HORIZON AND LOCALITY: In the Yang-Hu-Kou formation of Yang-Hu-Kou Shan-Tan-Hsien, Kansu. P. L. Yuan collector. Cat. G. S. C. 1591. The horizon is provisionally regarded as early Moscovian but may be late Viséen.

Hapsiphyllum altiseptum Grabau (sp. nov.)

Pl. IV, Figs. 6 a to g.

Corallum of moderate size, with an original length of perhaps 20 mm and a calicinal diameter of about 14 mm or somewhat more. Form conical, scarcely curved, rather rapidly enlarging; exterior well marked by costal grooves, with rather broad flattened interspaces. Calyx deep, the sides, though broken away in the typical specimen, apparantly descending vertically, then sloping towards the central area with the septa as sharply marked ridges upon the sides. Fossula pronounced, key-hole shaped with a very short but prominent cardinal septum of triangular section flanked on either side by a similar but small septum (probably tertiary) and by 4 well-marked secondary septa, which unite terminally to form the inner horse-shoe shaped wall. The position of the cardinal septum is well marked by the costal grooves and they are also somewhat more prominent in the calyx, especially near the inner wall, where they become bulbous. There are 7 septa in the counter quadrants, and all nearly alike, except the first pair which is slightly thicker. The most marked feature of the calyx however, is the prominent counter septum which is much thickened and projects into the calyx beyond the margins of the other septa. Tertiary septa are developed as triangular ridges between the secondaries.

Several cross-sections show further detail.

SECTION A. (Pl. IV, fig. 6 e.) This is 7.4 mm above the base and has a diameter of 8 mm. The wall is thickened by stereoplasm, having a thickness of somewhat less than 1 mm. The inner wall is key-hole shaped, but the sides only slightly contracted. It is bounded by a well-formed wall. The cardinal septum, which is of moderate thickness, projects into it nearly to the center of the corallum, its terminal end being united by strong dissepiments to the wall, thus forming a completely enclosed inner space. Another pair of dissepiments joins the septum to the inner wall, while further stereoplasmic thickening closes the peripheral end of the key-hole. There are altogether 4 secondary septa in the cardinal quadrants all joining to form the inner wall and all thickened by stereoplasm so that the inter-septal loculi are

reduced to tear-drops. There are also one or two series of dissepiments between each pair of septa. The alar septa are somewhat longer and thicker especially near their inner ends and the alar pseudo-fossulae are rather large. They are divided, however, by several dissepiments. There are 6 secondary septa in the counter quadrants, all united into one group with the counter, which is most prominent, and somewhat thickened at its lower end. The 1st pair of secondaries is almost as strong, but the others are somewhat thinner. Dissepiments sparingly developed and interseptal loculi teardrop form.

SECTION B. (Pl. IV fig. 6. f.). This is 2 mm or more higher than the preceding, and is reversed. It has a dorso-ventral diameter of 9 mm and a transverse diameter of 10.2 mm, and lies about 9 mm or more below the calyx rim. The inner walled area is prominent, of key-hole form, with the cardinal septum falling short of the center and terminated by bridging dissepiments which unite it with the inner wall. A second pair of dissepiments occurs lower down and the outer part is closed by stereoplasm. The septa are still united into 4 groups, the 2 counter groups being joined together by the much thickened counter-septum which penetrates the inner wall.

The cardinal pseudo-fossulae are still prominent and the number of septa has not increased, except in the right counter quadrant (left in figure), where the 7th secondary has appeared joining the preceding about mid-way, but it is not shown on the left. Tertiary septa faintly developed. This species is close to *H. delanoui* as figured by Carruthers from the Tournaisian of Bristol but the fossula is narrower, with more parallel sides and there are fewer dissepiments. But the most striking feature is the shorter cardinal and a very stout projecting counter in the calyx, while the alar septa are also more thickened centrally. The Chinese form furthermore is dorso-ventrally compressed instead of laterally. Nevertheless the species belongs to the same group.

HORIZON & LOCALITY: In the Choniukou formation of Viséen Age. Choniukou. Wuweih sien, Kansu. P. L. Yuan collector. Cat. G. S. C. 1592.

Hapsiphyllum moukouense Grabau (sp. nov.)

Pl. IV, Fig. 7 a to c, 8 a b, 9 a b & 10.

Corallum small, of the group of *H. delanoui*. A characteristic specimen with the calicular rim broken away, has a length of 10.2 mm and a maximum diameter of 6.4 mm. The exterior is somewhat irregular with contractions and faintly marked growth-lines, but with well-marked costal grooves, separated by rounded ridges. There is no pronounced curvature but the fossula is on the shorter side. The calyx apparently had

vertical sides, with a gently sloping base and an abrupt inner area bounded by a well-formed wall which has a key-hole form, with a circular central part and nearly parallel sides. The cardinal septum is short and there are 3 well-formed secondaries in the cardinal quadrant, with a thin newly formed 4th on the right side, where the septa are all united in a pinnate manner. They appear free on the left side, but that is an accident of preservation. The alar septa are radially placed and somewhat thinner than the cardinal secondaries, with the alar pseudo-fossulæ no larger than the other interspaces. The counter septum is the strongest of the opposite group, thickening slightly inward and projecting a little beyond the inner wall. On either side there are 6 secondary septa, nearly if not quite radial and all uniting to form the inner wall. The 6th is weaker than the others, especially on the left side where it still adheres to the preceding one. The tertiary septa, though indicated by the costal grooves, scarcely project beyond the calicular wall. There is no indication of dissepiments or tabulæ in the calicular view.

The base of the corallum shows irregular epithecal expansions indicating that the coral was affixed in an early stage.

This species differs from *H. altiseptum* in its more slender form and more rapid development, having already attained the full generic character at the stage when the other species is still immature, (see Fig. 6e, Pl. IV). It differs from *H. yuani* in its smaller size and more slender growth, more pronounced inner wall, and radial character of the counter secondaries.

Another specimen of this species (Pl. IV fig. 8 a b, Cat. 1595.) shows somewhat more irregular growth and slight curvature, with the cardinal septum nearly but not quite on the side of the greatest curvature. The walled central area is somewhat more irregular, owing to the shortening of the septa on the left but it still retains essentially the key-hole form. This specimen too is without the calicular rim, the length remaining being 10 mm while the diameter at the calyx base is 6.8 mm. There has been a slight constriction of the calyx, so that the actual diameter of the calyx is somewhat less. The cardinal septum is short as in the other case and there are only three secondaries on either side. The alars are again somewhat weaker, especially the one on the right side where there is an additional incomplete counter secondary still adhering to the preceding one. Altogether there are 7 secondaries in the right hand counter quadrant and 6 in the left all radially placed. The counter septum itself is thicker than the others and projects slightly into the inner cavity. No dissepiments are shown in the calyx but where the corallum is worn on the left, a few rather stout but distantly placed dissepiments are seen, their attitude being a nearly horizontal one. The base of this specimen too is irregular.

Two cross-sections of a 3rd specimen (Cat. 1596) are shown in Fig 9 a & b Pl. IV. Fig. 9a shows a young stage, the diameter being 3.5 dorso-ventrally and 3.7 transversely. The cardinal, alar, and counter, all meet in the center, the counter being thicker but the others are of small size. There are only 2 secondaries in the cardinal quadrants, the 1st pair meeting in the center to enclose the cardinal, the second joining the 1st about mid-way of their length. A single dissepiment ties the cardinal to the second secondary on the left and another ties the alar on the same side. There are 4 secondary septa in each counter quadrant all converging towards the counter septum and united by their inner ends. The 1st pair is thicker than the others. The counter septum is somewhat swollen at the inner ends and projects faintly beyond the others. It is somewhat less thickened than the 1st pair of secondaries. A few dissepiments occur. Tertiary septa are indicated in the majority of intervals by the deep costal grooves, but are otherwise undeveloped.

The second section nearer the calyx (Pl. IV Fig. 9 b) is imperfect, but still permits the determination of most of the characters. Its diameter is approximately 6.2 mm, but may have been a little more. The cardinal septum is still long, projecting to the center where it is slightly thickened and enclosed by the 1st pair of secondaries. There appear now to be 3 secondaries in the left cardinal quadrant while on the right only 2 are shown. There may be a third, but the specimen is broken. The alar septa are rigidly radial. The counter septum is slightly thicker than the others which are also radial and slightly thickened inwards. There are 5 fully formed secondaries with an incomplete 6th on the right side adhering to the 5th. A single ring of dissepiments is shown.

It is possible that these sections do not belong to the same species, though from the general appearance of the specimen, before sectioning, that seems to be the case. In any event, they represent more primitive conditions with the inner wall still undeveloped and the individual may be less accelerated.

A longitudinal section (Pl. IV Fig. 10, Cat. 1597) with a preserved length of 9 mm and a maximum diameter of 6.7 mm, showed the normal character of the species with the strong counter septum before sectioning. The interseptal loculi cut in the section are deep and show a total absence of dissepiments. In the central part the septa are in close conjunction because of stereoplasmic thickening and the whole basal part is solid with stereoplasm.

HORIZON AND LOCALITY: This species seems to be common in and characteristic of the Moukou formation believed to be of Moscovian age and characteristically developed at Moukou, Fu-I-Hsien, Kansu, where it was collected by Mr. P. L. Yuan. Most

of the specimens are small, but an occasional form apparently of this species may reach a length of more than 20 mm. Types in the Geological Survey of China Collection, Cat. 1594 (Holotype), 1595, 1596 & 1597, also 1602, (paratypes).

Hapsiphyllum elegantulum Grabau (sp. nov.)

Pl. V, Figs. 15-19.

Corallum small, conical, scarcely curved, very gently enlarging, three of the individuals illustrated showing the following dimensions etc.

Cat. No.	Length	Calicinal diameters		Basal diam.	Counter quadrants		Cardinal quadrants		Figured Pl. V
		d.-v. diam.	tr. diam.		Total No. of septa	Estimated Number of Secondaries	Total Number of septa	Estimated Number of Secondaries	
1634	8.6	8.2 mm	7.0 mm	1.8	10	5	7	3	16
1635	10.8	6.5	7.2	1.7	11	6	7	3	17
1636	6.1	4.9	5.7	1.9	10	5	5	2	15

These specimens all have their calices filled, and it is therefore not possible to ascertain the exact number of septa, but where they can be seen the secondary septa correspond to every second groove. The corals all show a more or less expanded base with a scar of attachment. The epitheca shows lines of growth and a few wrinkles and is very strongly and regularly marked by deep costal grooves and intervening ridges. Most strong of the latter are those bounding the cardinal groove, so that in all cases the cardinal septum is easily determinable, the bi-pinnate arrangement of the other groups also being well-marked. Nearly as strong are the ridges bounding the alar grooves, and here the uni-pinnate arrangement of the grooves in the counter quadrants is equally well-marked. These features are very striking and permit recognition of the species by the exterior. In sections it is shown that the tertiary septa are undeveloped being indicated only by the grooves, which are often shallower than those indicating the other septa.

A specimen was sectioned 4.9 mm above the base (Cat. 1628 Pl. V, Figs. 18a) which itself shows a marked scar of attachment. The dorso-ventral and transverse diameters of the section are respectively 5.8 and 6.2 mm. There are 3 secondaries shown in the cardinal quadrants and 5 in the counter. The cardinal septum is thin but continuous, and with a very broad pseudo-fossula on either side. The other septa

are all united by a thickening of their stereoplastic ends, except in one case, where the 4th secondary septum in the right counter quadrant has its thickened ends bent hook-wise and lying free in a lateral gap which opens into the central gap. This however, is merely an individual aberration. A further aberration at this stage is that the thickened inner septal ends meet in front of the cardinal septum and separate the pseudo-fossulæ from the central hollow area. The counter septum is slightly more thickened than the others, but the alar are essentially like them. Tertiary septa not shown and dissepiments absent.

A section about 1 mm higher and about 6.3 mm below the calyx rim has a transverse diameter of 7.0 mm and a dorso-ventral one of somewhat less, but not determinable because of the imperfection of the specimen. The cardinal gap is now freely open to the center, the cardinal septum itself being aborted to a mere point. The secondaries in the cardinal quadrants are still united and to them on the left (right in the figure, which is reversed) are joined the 2nd to 5th secondary septa of the corresponding counter quadrant, while a 6th is half-way developed, joining the 5th. On the opposite side *i.e.* the right, (left in Fig 18b) the alar and the counter secondaries are free. The counter septum itself projects only about half-way to the center and ends freely. Tertiary septa are seen in the calicular wall and in a few cases project beyond it as short spines.

A thin section made from another individual (Cat. 1562, Pl. V, Fig. 19) has a dorso-ventral diameter of about 7.5 mm or somewhat more, the section being imperfect. The transverse diameter can also not be determined. Here the free central area is key-hole shaped opening into the septal gap, which widens marginally and carries the aborted cardinal septum.

There are apparently 3 septa in the cardinal quadrants and 7 in the counter, though on one side (the left), the section is imperfect and there may be only six. (The section as drawn is somewhat restored.) The septa of the cardinal quadrants and the alar are still closely united, chiefly by the contact of their thickened inner ends. The others become progressively free towards the counter septum which is somewhat longer than the others and very distinct, and flanked by a shorter counter lateral on each side. Tertiary septa scarcely developed. Dissepiments wholly absent.

This form is at the same time more simple and more complex, than the other species of *Hapsiphyllum* described. It is more simple in the total absence of tertiary septa and dissepiments or tabulæ and more specialized in having the septa free at an early stage. It may eventually be shown that this is not a true *Hapsiphyllum* but represents another generic type.

HORIZON AND LOCALITY: In the Moukou Limestone of Moukou. Fu-I-Hsien. Kansu, (Locality 510) Collected by P. L. Yuan. Cat. 1632 and 1634 to 1636. also Cat. 1628.

A single specimen with the external characters of this species has been obtained from the Yang-hu-kou formation (Moscovian) of Yang-Hu-Kou, Shan-Tan-Hsien. Kansu. Cat. 1638.

Hapsiphyllum magnolacunum Grabau (sp. nov.)

Pl. VI, Figs. 6 a to 6 c.

Corallum horn-shaped, slenderly pointed at the curved base, but rapidly expanding, so that at a length of about 18 mm it has a diameter of about 12.5 mm. The adult portion of the holotype is crushed, but from what remains it is apparent that the calyx was of fair depth marked by septa in the form of ridges on the steep sides, and meeting in the center of the calyx around a very large fossular lacuna surrounded by an inner wall, open towards the cardinal side. Exterior with the epitheca strongly ridged, because of the well-marked costal or septal grooves. The cardinal septum is located on the concave side of the corallum and its groove is marked by two strong flanking ridges, much broader than those that intervene between the secondary septa and broader too, than those bounding the alar septa.

The corallum was sectioned at a length of 8.5 mm from the base at which point the dorso-ventral and transverse diameters are 7.4 and 6.2 mm respectively. The outline here is ovoid, this probably being to some extent the result of compression if not entirely so. At this stage there is a total of 7 septa in the left and 8 in the right cardinal quadrant as indicated by the septal grooves. Of these 4 appear to be secondaries in each case, these uniting and forming the lateral part of the very large elongated fossular lacuna. Into this the cardinal septum projects slightly, but because of the extreme stereoplastic thickening, it is completely joined to the adjacent septum, so that the aperture of the lacunal wall is closed on the cardinal side.

The alar septa are not distinguishable from the others but their location is shown by the septal grooves. The total number of septa in each counter quadrant is 12 of which 6 are secondaries and 6 tertiaries, the latter, both in the counter and cardinal quadrants, being only slightly developed and indicated chiefly by the costal grooves. The secondary septa all curve towards the counter septum uniting with it and with one another to form the upper part of the inner wall, to which the cardinal secondaries are joined by the alar septa. All the septa are excessively thickened, so

that they form a solid mass of stereoplasm in which only a few inter-septal lacunæ are visible on the left side. This stereoplasmic thickening apparently continues to the calyx as indicated by the section a short distance below it. (Pl. VI, Fig. 6c).

This species is distinguishable from others with which it is associated by the very large fossular lacuna. In the young stage the septa retain a very strongly pinnate character, which is very similar to that shown in some specimens of *H. delanouei*. E. & H. (vide Carruthers 1908 pl. V, fig. 6 a), but the cardinal septum is shorter and the lacuna is more pronounced. Although the adult characters cannot be fully determined because of the crushed condition, the coral is so distinct in its form and the character of the immature section that it is readily distinguished from the other species.

HORIZON AND LOCALITY: In the Viséen Beds of Tung-Wa-Kou, Wu-Wei-Hsien, Kansu. Locality 547, Collected by P. L. Yuan, Cat. 1643.

Genus **ALLOTROPIOPHYLLUM** Grabau (gen. nov.)

Corallum simple horn-shaped, curved or more rarely straight, sometimes strongly bent. Exterior with growth-wrinkles, growth-lines, septal grooves and, in the typical species with irregularly scattered hollow spines. Calyx moderately deep with sides steep and base more or less flattened, both secondary and tertiary septa generally shown, the cardinal in a more or less pronounced fossula the other primaries not especially differentiated. Central area flat, non-septate, but with tabulæ enclosed by a usually complete inner wall or phyllothea, formed by the junction of the septal ends, with the cardinal gap bridged over by one or more dissepiments. Counter quadrants highly accelerated in type species with 3 to 4 times as many secondaries as the cardinal quadrants. The counter secondaries join the inner wall, the cardinal secondaries sometimes partly free, at others attached to the inner wall, the conditions being very variable. Enclosed inner area varying in form from semi-circular to elongate circular or irregular with the line of the cardinal septum often reaching it obliquely.

GENOTYPE: *A. sinense* Grabau (*Amplexus spinosus* var. *sinensis* Grabau)

HORIZON AND DISTRIBUTION: Known at present only from the Carboniferous (Chihhsia limestone) of Central China.

Allotropiophyllum sinense Grabau

Pl. V, Fig. 1-3, 4 a-e, 5 a-b, 6 a-c.

1922. *Amplexus spinosus* var. *sinensis* Grabau, Pal. Sinica, this Series & Vol. fascicle 1. p. 64, Pl. 1. Figs. 22 a-b, 23.

During the preparation of the first fascicle only a single more or less silicified specimen was available. Since then many have been collected from the type region at

Chihsia-Shan, and from the same formation elsewhere. Several of these permitted the preparation of thin sections, which showed characters not always preserved in the silicified form.

External form varies considerably as does also the size of individuals. A specimen illustrated in Pl. V. Fig. 1 is abruptly bent at the base to an angle of 180° . The short end has a length of about 4 mm, after which the coral continues for a length of 11 mm more, expanding regularly to a calicinal diameter of 8.3 mm. The septal grooves are faint, though shown, but the growth wrinkles are strong. Spines are irregularly scattered over the surface, the average basal diameter of these being 0.8 mm. Their original length was several mm and they were apparently hollow. The calyx is moderately deep, almost the full depth being shown in the specimen illustrated in Fig. 3, Pl. V. Here the depth is 6.5 mm, while the diameter is 8.5. The sides descend steeply to the flat bottom and are marked throughout by the principal septa, the tertiaries only appearing in the upper part of the calicular rim. The central flat area is about 2 mm in diameter and is well defined, though no wall is shown. The tapering in this form is very gentle, the diameter being 5.3 mm at a distance of 12.5 below the calyx rim; few spines are shown and in the broken portion the median tabulæ are clearly seen.

A somewhat larger specimen shown in Fig. 2 Pl. V, has a preserved length of about 20 mm, the base being imperfect. The calicinal diameter is about 12 mm and the depth of the calyx about 7.5. Externally the septal grooves are well marked. Wrinkles and growth lines are numerous, but spines are few and scattered. The diameter of the central area is 3.3 mm and it shows a distinct wall, while the septal ends are thickened especially in the counter regions. The cardinal fossula is on the concave side and well marked from the shortening of the cardinal septum. All the septa are radially disposed and of triangular section with a sharp summit. Tertiary septa appear in the upper rim of the calyx. The position of the alar septa is indicated by the grooves. These show that there are 2 secondaries in the cardinal quadrant and 8 in the counter thus showing extreme acceleration.

Other specimens show occasional constriction of the calyx, with the effect of rejuvenescence shown by cup and cup arrangement. When silicified, the central part of the septa may dissolve, leaving only the stereoplasmic thickening, whereupon the septa in the calyx appear to be divided by a median groove. When sectioned longitudinally, irregular, somewhat cystose tabulæ appear, which bend downward at the margin, forming tabuloid dissepiments between the septa. In the center they are somewhat cystose.

SECTIONS

A fairly complete series of sections has been obtained from 1 specimen (Cat. 1600 the Holotype). These are shown in Pl. V, Figs. 4 a to e. The following are the dimensions.

Section	Dorso-ventral	Transverse	Interval	Plate V
a	2.2 mm	—	} 4.7	Fig. 4 a
b	4.8 mm	5.0		Fig. 4 b
c	5.5 mm	5.4	} 3.3	Fig. 4 c
d	7.2 mm	6.8		Fig. 4 d
e	8.2 mm	7.7	} 8.5	Fig. 4 e
f*	—	8.0		—

In section a, the 4 principal septa are shown all much thickened by stereoplasm. In addition there appears the 1st pair of counter secondaries and an indication of the 2nd pair.

SECTION B. In this section 5 secondary septa have appeared in the counter quadrant on the right and 6 on the left. All the septa converge to the counter septum from each side, the curvature of the septa increasing outward in each direction. The 6th septum on the left side is only partly formed, joining the 5th midway *i. e.* at the point of curvature. The 5th septum on the right is also slender but complete. In both cases the last septum is joined to the alar by a dissepiment. All the counter septa form by their ends a continuous horse-shoe-shaped wall which is thickest on either side of the counter septum. The alar septa are long and curved and extend into the horse-shoe, abutting mid-way against its lateral wall. The same thing is true of the 1st cardinal secondary, which still unites with the alar on the left, but is free on the right. The alar and 1st secondary are moreover united by dissepiments of which there are 4 on the left and 3 on the right. The second cardinal secondary extends only part way into the gap, its ends abutting against the 1st to which it is also tied by one or more dissepiments. Furthermore the ends of the two second cardinal secondaries are joined across the gap by a stout dissepimental bridge, thus completely isolating the central area and enclosing it by a complete wall. A second thinner dissepiment extends straight across, about one third the distance lower down likewise uniting the two septa. The cardinal septum has a length of about $\frac{1}{3}$ that

* The calyx

of the second secondaries or $1/4$ that of the entire gap. It too is joined to the secondaries by two slender arched dissepiments which extend from the tip of the cardinal septum to the sides of the secondary.

There are only 2 secondaries in the cardinal quadrants and this is the number remaining throughout, while the number in the counter quadrants increases. Tertiary septa occur in all the intervals between the alar and cardinal, but they are short and triangular. They do not occur in the cardinal pseudo-fossule nor between the last 2 counter septa, but appear in all the other intervals. A few irregular dissepiments occur between the counter secondaries, the stoutest and most prominent one joining the counter and 1st lateral septum on the right.

SECTION c. This section is reversed with reference to the preceding. The 6 secondaries on the left (right in the figure) are well marked, the 6th now being nearly complete. On the right (left in the figure) the 6th has just appeared being a short branch of the 5th. All the septa continue to be united in the horse-shoe-shaped inner wall and the alar and 2 cardinal secondaries on the right (left in the figure) are also united with this, so that the wall on this side appears to be continuous with the last secondary septum as in *Hapsiphyllum*. On the left however (right in fig.) the conditions are different. The alar septum still extends into the gap and much further than in the preceding section, the wall on this side being formed entirely by the counter secondaries. The second cardinal secondary on this side is very long, extending through the middle of the gap in a straight line to the center of the wall opposite the counter septum. An oblique dissepimental bridge ties the end of this septum to the alar, and the 1st secondary on this side, symmetrically placed between the alar and second secondary, extends to this dissepimental bridge. There are 4 dissepiments joining the two secondaries on this side, and 5, one of them oblique, joining the 1st secondary to the alar. The alar itself is joined by 3 dissepiments to the counter secondaries, between all of which, one or more dissepiments appear. On the right side (left in fig.) the dissepiments are somewhat less numerous, but nevertheless present.

The cardinal septum is even shorter and more sharply pointed. It occupies about $1/5$ the length of the gap and is joined by 2 dissepiments which extend from a little behind its terminus to the adjoining secondaries where these merge with the calicular wall. Three other dissepiments extend across this part of the gap, joining the 2nd cardinal secondaries and completely shutting off the now much narrowed inner area. Tertiary septa as in the preceding section.

SECTION d. In this section 8 secondary septa have appeared on the left side, all of them fully formed, though the 8th is slightly thinner and all of them joining to form the inner wall which is continuous with the 8th septum on this side. On the

right side on the other hand, there are only 5 complete septa, the 6th one joining the 5th midway. The alar septum on this side is strong and forms the continuation of the inner wall. The 2 cardinal secondaries on this side unite terminally and abut against the inner end of the alar but take no part in forming the inner wall. Dissepiments between these and on either side of the alar are well developed. They are more sparing between the counter secondaries on this side.

On the left the alar septum extends freely into the gap, its upper part being bent obliquely and extending across the gap as a bridge to the opposite wall near the inner end of the right alar. From the elbow of curvature a straight septum joins it to the wall on the left, thus again enclosing an inner space which now approaches a semi-circular form. There are at least 4 other dissepiments, joining the alar to the 8th counter secondary on the left. The 1st of the cardinal secondaries abuts against the alar just beyond the elbow. The second ends freely a little before. In both intervals there are from 5 to 6 dissepiments. The cardinal septum is slightly longer in proportion and tied by stout dissepiments to the adjoining secondaries, these appearing near the end. Two other complete and one incomplete dissepiments unite these secondaries. Dissepiments are also somewhat more numerous in the intervals between the secondaries in the left counter quadrants occurring in all the interspaces, the alar pseudo-fossula included. The tertiary septa are fairly well developed in all the interspaces, except the alar pseudo-fossulae and the space between the last two counter secondaries on either side.

SECTION E. This is again reversed and, the inner wall is now symmetrically placed and of regular semi-circular outline and a straight face on the cardinal side, where it is supported by the cardinal secondaries and alars. In outline it suggests a mushroom on a slender stalk which is formed by the second cardinal secondary on the left. On this side both secondaries as well as the alar and the last counter secondary abut against this flat base, while the other counter secondaries join the arched surface. There are 8 counter secondaries on this side. On the right (left in the figure) there are still only 5 complete counter secondaries, all of which join the arched surface of the central area. The 6th secondary on this side, however, has become much longer, joining the 5th near its inner end. It is still, however, thinner. The alar on this right side joins the angle of the inner semi-circle, while the 2 secondaries of the right cardinal quadrant abut against its base. The cardinal septum reaches a little less than half way to the flat base of the inner wall and ends freely. In front of it, however, there are 3 dissepiments, tying together the inner secondaries, the upper end of this cardinal gap being furthermore closed by the flat base of the inner wall. The Tertiary septa are well-developed, being longest on either side of the cardinal and

on either side of the counter septum, but absent in the spaces free from them in the preceding sections. Dissepiments are fairly numerous, especially in the cardinal region.

CALYX: The calyx is partly shown and has the septa essentially radially placed, stopping abruptly at the inner space, which appears again circular. They no longer form a distinct wall, but end freely, though in most cases, their inner ends are strongly thickened and this together with a ring of dissepiments encloses the inner space which is flat-bottomed. The cardinal septum is short, producing a well-marked fossula and the tertiary septa are fairly prominent.

The exterior of this individual is very beautifully marked by deep and broad septal grooves separated by sharp and narrower ridges. Spines are rare on this individual, and growth-wrinkles are subdued.

Another specimen from the same horizon and locality with deep paralld sided calyx has been thin-sectioned. On this specimen, the wrinkles are more prominent and the costal grooves less so, being shallow and linear while the intervening ridges are broad and flat; spines are however well-developed on the middle part of the corallum. Cat. 1593).

A section nearly 10 mm above the base (Pl. V, Fig. 5a) has a diameter of 6.7 mm. In point of preservation there is some inequality, the inner ends of some of the septa, being more nearly of the colour of the filling matrix and so not apparent at first glance. They are, however, readily seen with proper illumination. Here again the central area is completely enclosed and sub-semi-circular, but with rounded ends. The central ring appears in section to be supported by the two left cardinal secondaries and by the left alar, all three of which meet the flattened side of the central ring. The sixth secondary on the left also joins the base while the other five join the end and top. The cardinal and counter septa are placed obliquely with reference to the central part but the quadrants are equally accelerated, there being 6 secondaries in each counter quadrant and 2 in each cardinal. The two secondaries of the right cardinal quadrant join the base of the ring but the alar and 6 secondaries of the right counter quadrants join the side and top. The fifth secondary is defective and indents the side of the central tube. Tertiary septa are well developed in all the interspaces, including the alar pseudo-fossulae. No dissepiments are shown in this section.

Another section taken about 7 mm below the calyx rim (Pl. V, Fig. 5 b) has a diameter of 8.6 mm. In this section the central tube and principal septa are symmetrically placed, the two cardinal secondaries and the alars joining the counter secondaries to form the inner wall much as in *Hapsiphyllum*. The cardinal septum is

short occupying only about one fourth the length of the entire gap, central area included. Its terminal end is tied to the secondary on either side by a strong dissepiment. Two other strong dissepiments occur at the ends of the septa, bridging over the gap. At least one dissepiment occurs in the other interseptal spaces, these being arranged more or less in a ring. There are six counter secondaries on the right and seven on the left all bending to the counter septum. The ends of most of the septa are slightly thickened. Tertiary septa occur in all the interspaces.

HORIZON AND LOCALITY: In the Chihhsia limestone of Chihhsia Shan, Nanking region, Kiangsu. Common.

Figured types: Cat. 1593, 1599, 1600, 1602, 1604, 1606, (Cat. 1600, Pl. V. Fig. 4a-d. Holotype, the others Paratypes)

Additional Paratypes Cat. 1598, 1601, 1603, 1605, 1608, (not figured)

Allotropiophyllum sinense Grabau, var. **heteroseptatum** Gr. (var. nov.)

Pl. V, Figs. 6 a-c.

A single specimen in a rock matrix from the Yanghsing limestone of E. Hupeh has been thin sectioned and shows certain characters which suggest that it is a distinct form.

The diameters and septal numbers of these sections are as follows:

Section Cat. 1607	Dorso-ventral Diameter	Transverse Diameter	No. of Secondary Septa			Figured
			Cardinal Quadrant	Counter quadrant		Plate V
				left	right	
a	5.2 mm	5.0 mm	3	5	5	Fig. 6 a
b	6.4 mm	5.9 mm	3	6	6	" 6 b
c	7.7 mm	8 ? mm	3	7	7	" 6 c

These sections show that the main distinction lies in the presence of three secondary septa in the cardinal quadrants with a corresponding reduction in the number of septa in the counter quadrants.

SECTION A. In this section the central tube is open on the cardinal side, the cardinal septum projecting freely into the central space. It is however, tied to the adjoining secondaries by a dissepiment on either side, at about its mid-length and another near its base, while near the inner end there are two faint dissepiments on the

left. The three cardinal secondaries and the alar unite into a single group which projects into the central area on the right, but abuts against the inside of the wall, the wall on this side being formed by the counter secondaries. On the left the cardino-alar group coalesces with the inner wall. The counter septum is straight but placed somewhat obliquely. The five secondaries on either side converge towards it and join to form the tube. Dissepiments are scattered. Tertiary septa in all the interspaces.

SECTION B. In this section the inner wall is somewhat less perfect. On the left side it is continuous with the 6th secondary septum, the next one beyond it joining the three following and projecting with them into the inner cavity. This suggests that the number of secondaries in the counter quadrant is 6, and that there are 3 secondaries in the cardinal quadrant instead of two. It is not possible to determine this point precisely as the specimen sectioned was embedded in rock, and the septal grooves were not exposed. On the right the case seems to be similar but less clear. The seventh septum from the counter unites with the 8th and 9th, forming a group which projects hook-like into the inner cavity while a tenth septum on that side close to the ninth, projects about half way to the center. The cardinal septum has a length of about one fourth the distance to the center and its end is tied by a stout septum to the shorter secondary on the left and the longer on the right.

If these relationships indicate that there are only six counter secondaries and three cardinal ones, we have here a feature sufficiently distinct to make it desirable to consider this individual as representing a distinct species, but as the exterior of this form is not determinable it seems best to leave it for the present under *A. sinense* Gr. as a variety.

Dissepiments are mostly confined to a single cycle, and tertiary septa are well developed.

SECTION C. In this section the counter septum is slightly bulbous on the lower end, straight, and joined on the left by a rather stout straight septum. This and the six succeeding, or seven in all on this side curve counter-wards to form the wall. The eighth which may be the alar, projects freely into the inner cavity but is tied to the preceding one by several dissepiments. The 9th and 10th are also free, though supported by one or two dissepiments along their length. The eleventh is of the same character but joined to the corresponding one on the right side by a terminal oblique dissepimental bridge, against which the more slender cardinal also abuts. This is further supported some distance from the end by a pair of stout dissepiments, and others occur further down.

On the right the wall divides. The outer part involves the first three secondaries, while the next three end in free points but are united with the outer

branch of the wall by stereoplasm. From the end of the seventh, on the right, a curved dissepiment extends to the inside of the central wall opposite the counter septum, forming the inner branch of this wall, but not touching the other secondaries on that side. A left branch of this dissepiment joins the bridging dissepiment uniting the terminal end of the cardinal and adjacent secondary on either side.

Here too it would appear that there are three secondaries in each cardinal quadrant instead of two, and seven in each counter quadrant, although the last of these on the right is distinct from the others and the 4th, 5th & 6th also show a tendency to become free.

Tertiary septa are well developed and dissepiments occur in two or more cycles.

As stated above, the exterior of this specimen is not known and it can not be stated whether there are spines or not. Nor can the actual relationship of the septa be ascertained except in the aspect of the section.

HORIZON AND LOCALITY; Yanghsing limestone (Upper Carb.) Fuchikou, Yanghsinghsien Loc. 803 E. Hupeh. Coll. C. C. Liu & Hsieh; cat. 1607.

Genus **MENISCOPHYLLUM** Simpson

(Text figs. 22, 1-4)

1900. Simpson, G. B. Preliminary descriptions of new Genera of Palæozoic Rugose Corals. Bull. N. Y. State Museum No. 39, Vol. 8 p. 199-200 Text fig. 1-4.

This genus is apparently a simplified member of the family Hapsiphyllidæ as indicated by the union of the septa of the counter quadrants into an incomplete inner wall re-enforced by stereoplasmic thickening.

Simpson gives the following generic description. "Corallum minute, horn-shaped regularly curved, calyx circular deep; septal fovea conspicuous, situated on the side of least curvature; septa apparently of the same size, but probably the smaller ones only rudimentary, and, except in unusually well-preserved specimens, obsolete. The extremities of the septa situated on the side of the greatest curvature become thickened and coalesce, forming in connection with a deposit of stereoplasm a thickened axis or pseudo-colum-



Fig. 22 *Meniscophyllum minutum* Simpson 1. Side view of a specimen natural size; 2. longitudinal section enlarged; 3, 4, transverse sections showing the crescentiform appearance of the pseudo-columella enlarged; Lower Carbonic, Missouri (After Simpson).

ella. In a longitudinal section this axis has the appearance of the columella of *Cyathaxonia*. In a transverse section it is crescentiform; tabulae present, dissepiments not observed.

"This genus most nearly resembles *Menophyllum* E. and H. but there is only one septal fovea and the crescentiform thickening appears only in section and is formed in a different manner from that of *Menophyllum*".

GENOTYPE; *Meniscophyllum minutum* Simpson. Mississippian of Missouri.

The type species is a very small curved coral about 12 mm high, the calyx about 7 mm in diameter and it has about 16 or 17 long septa and an equal number of shorter ones. All of these, except 2, or in some cases 4, coalesce with the thickened wall, Simpson's pseudo-columella, which lies on one side of the center *i. e.*, the one of greatest curvature. In section this pseudo-columella is distinctly crescentiform, suggesting a much thickened inner wall, open on one side, the ends of the crescent continuing in a septum to the outer wall. Into this more or less horse-shoe-shaped fossula, project two of the septa, but which septa these represent it is impossible to glean from the illustration or the description, which is the more to be regretted, since apparently the costal grooves are well marked, and it would have been possible to identify the principal septa. If the side of greatest curvature is the cardinal side, as seems to be indicated by the faintly represented costal grooves in Simpson's Fig. 1, where apparently an alar septum is shown on the side, then the horse-shoe-shaped fossula, with its two septa projecting into it, represent the counter side, and it might be suggested that these two septa represent the counter laterals, the counter itself being aborted. This however does not get us much further, since the remainder of the septa in this section (Fig. 4) which join the crescentiform pseudo-columella, number 14 in all, thus placing 2 septa instead of one opposite the fossula, and in the position of the cardinal septum. In another section however, Fig. 3, the septa joined to the pseudo-columella number 13, and a single septum, the shortest of the series, lies directly opposite to the horse-shoe-shaped fossula; which is here occupied by 4 free septa instead of 2. This orientation is however contrary to that found in all other related corals, and we must conclude that the cardinal septum lies on the side of least curvature and of the fossula. This is the position occupied by these septa in the Chinese species referred to this genus. It is evident that more detailed study of this type is necessary, before its true relationship is ascertained.

CHINESE SPECIES.

Meniscophyllum kansuense Grabau (sp. nov.)

Pl. IV, Figs. 4 a to e.

A single specimen has been obtained which appears to belong to the genus *Meniscophyllum* although because of a lack of longitudinal sections it has not been possible to elucidate the internal structures completely. The corallum is small, short, conical and with a slight curvature and with the costal grooves well-marked on the exterior. A series of transverse sections has been prepared showing the general character of the septal arrangement. The youngest section (Pl. IV, fig. 4 a) has a diameter of 2.5 mm. This is entirely filled with light calcareous material, partly stereoplasmic enlargement of the septa, which are, however, indicated by the dark lines. The arrangement is somewhat heterogeneous, the septal lines forming an irregular cross, each arm of which has a number of short branches proceeding from it. This fact makes it impossible to locate the cardinal septum. Altogether there seem to be 13 or 14 septa in all. The following are the dimensions of the succeeding sections with the interval between them.

Section	Dorsal Ventral	Transverse	Interval	Pl. IV
b	5.0 mm	4.4	} 9.3	—
b ¹	5.2 mm	4.8		Fig. 4 b.
c	5.8 mm	5.3	} 1.3	" 4 c
c ¹	6.5 mm	5.6		" 4 d
d	7.1	6.5	} 1.4	—
d ¹	7.6	6.8		" 4 e

In section b¹ the cardinal septum is more slender than the others and reaches to the center, which with the two well-marked pseudo-fossulae forms a key-hole-like structure, the last pair of cardinal secondaries being slightly concave. A group of 4 septa appears on either side of the cardinal, all of them considerably thickened by stereoplasm and all uniting into a solid stereoplasmic mass for half their inner length. Three of these represent secondaries of the cardinal quadrants while the 4th is the alar septum. Beyond the alar septum are 2 well-marked alar pseudo-fossulae. The counter septum is stout and unites half way to the center with the stereoplasmic mass which unites the secondary septa. Of these there are 4 fully formed in each quadrant and a 5th one at the alar pseudo-fossula about half the length of the others and joining the

4th one. The interocular spaces between the secondary septa are considerably smaller than those on either side of the counter septum, thus the septa appear united into 4 groups. (Pl. IV, fig. 4 b.)

In section b, the 3rd pair of cardinal secondaries is less strongly developed and there is more stereoplasmic thickening in the whole mass. The 5th pair of secondary septa in the counter quadrants has not yet appeared. Tertiary septa are indicated only by the costal grooves. No dissepiments or endothecal structures.

SECTION C. (Pl. IV, Fig. 4 c reversed) In this section the stereoplasmic mass has been much reduced, the cardinal quadrants being entirely free from it. The 3 cardinal secondaries taper to a point, the 1st reaching $\frac{2}{3}$ the way to the center, the others being regularly and progressively shorter, while the cardinal septum is very short and triangularly pointed, thus producing a large fossula which extends as an open space to the center. The counter septum and the 5 well developed counter secondaries on each side are all united by an irregularly crescentic stereoplasmic arch, to which also the ends of the alar septa are joined. This mass is in reality due to the somewhat thickened ends of the septa of which the counter is somewhat longer than the others. The calicular wall too, is somewhat thickened by stereoplasm. There are no dissepiments or tabulae present.

SECTION C'. (Pl. IV, Fig. 4 d) This is 1.3 mm higher. The septa are all free, tapering towards the center, usually somewhat flexed toward the ends. The shortest is the cardinal, the alar are longer but still fall short of the adjoining secondaries, but the counter is the longest, having a length of nearly 2 mm, thus reaching a little more than half way to the center. All septa are radially disposed and there is an entire lack of dissepimental or other endothecal tissue. Tertiary septa only indicated by costal grooves. The number of counter secondaries is still 5 and of cardinal secondaries 3, making a total of 20 septa.

In section d, the conditions are similar but all the septa have now been shortened until they project only about $\frac{1}{3}$ the distance to the center. All the septa are now alike, so that it is not possible to distinguish the 4 principal septa except by reference to the other sections. The tertiary septa are now represented by slight bulging in the calicular walls between the longer septa.

SECTION D. 1.4 mm higher (Pl. IV, Fig. 4 e). Here the septa are still shorter, being represented on one side merely by slight ridges, but somewhat longer on the other. The tertiary septa are slightly more pronounced than in the preceding section, but do not project into the calyx.

What appears to be the section of a young coral of this same species lies freely within the calicular rim. (Pl. IV, 4 e). The outline is irregular, probably owing to the

obliquity of the section. The dorso-ventral diameter is 3.1 mm and the transverse diameter 2.8. The cardinal and alar septa are short. There are 3 cardinal secondaries united on one side but free on the other. There are 5 counter secondaries, the last 3 of which are united on one side, the others are free. None of the septa reach more than $2/3$ the way to the center and there is no endothecal tissue.

This species resembles *Meniscophyllum minutum* Simpson, the genotype from the Lower Carbonic of Missouri, in the crescentiform stereoplasmic mass, which unites the septa of the counter-quadrants. The number of septa in that species however is much less, there being only 17 of these in the larger section (Text Fig. 22-3) four of which are free. As previously suggested, these may represent the secondaries of the cardinal quadrants, the cardinal septum itself being wholly aborted. If that is the case the alar septa are the first to unite with the crescentic mass and there are 5 secondary septa in each counter quadrant. The presence of the thin tabulae is not indicated in the cross-sections and they may occur in our species as well. In length and diameter the two species agree fairly well.

HORIZON AND LOCALITY: In the Yanghukou Formation (Moscovian) of Yang-Hu-Kou, Shan-Tan-Hsien, Kansu; P. L. Yuan collector, Cat. G. S. C. 1590.

Genus **AMPLEXUS** Sowerby

CHINESE SPECIES PROVISIONALLY REFERRED TO THIS GENUS.

(See fascicle I page 60)

Among the material collected from the Silurian Rocks of the Yangtze Valley are a number of specimens of Amplexoid types, which in the present state of our knowledge of the genus *Amplexus* can only be referred to it. It must, however, be again emphasized, that we are as yet unable to give a full definition of the genus since the early stages of the type species *A. coralloides* of the British Lower Carboniferous seem still to be unknown. It seems hardly tenable that a generic type of this kind should have such an extended range as is implied by the reference of Lower Silurian (Niagaran) forms to this genus. It is far more likely that the types now included under this generic name, because of their amplexoid character, represent a polyphyletic group, the typical amplexiform characteristics reappearing in diverse phyletic series. In default of detailed information regarding the ontogeny of the type species, we are, however, constrained to place these species, at least provisionally, under that genus.

Amplexus lojopingensis Grabau (sp. nov.)

Pl. V, figs. 8-13

Corallum elongate, digitiform, commonly irregular with numerous contractions, sometimes curved and with strongly wrinkled epitheca and well-marked septal grooves, indicating numerous septa. The young is conical, curved and rather rapidly expanding (Fig. 9, Cat. 1618), reaching a diameter of 8.5 mm at a length of about 10 mm. This portion is very irregular and streptelasmoid in character with the principal septa indicated by the costal grooves, the cardinal septum being on the outer or convex portion and the alar upon the sides. From the disposition of the latter, it would seem as if the distribution of the septa in the quadrants is essentially uniform, although from the state of preservation it is not possible to ascertain this with any degree of certainty. It is however evident that even at this early stage the amplexoid character is already developed, the septa being restricted to the marginal portion, while the diameter occupied by the tabulae is slightly over 6 mm. The calyx is rather deep with steep sides and a flat floor formed by a tabula. Only rarely do the septa run out on the tabulae towards the center at this stage. The latter are closely crowded and thin, usually continuous across the calyx. There is no fossula.

The several illustrations herewith given, show the general variation in form of this species together with the usual size, which rarely exceeds 17 mm in diameter and generally is less.

A series of cross-sections of a single individual is shown in figures 12 a to c. In the 1st of these, Fig. 12a, the maximum diameter is 12.3 mm and the minimum 11.3 mm. The calicular wall is thickened by stereoplasmic matter to a maximum of 1.7 mm. Through it project the septa which are of variable length, but in no case does the length exceed twice the thickness of the wall. Altogether there are some 63 or 64 septa, longer and shorter ones usually alternating, the shorter scarcely projecting beyond the calicular wall. There is, however, some irregularity. The septa are wedge-shaped, those projecting beyond the wall tapering to a rather slender point, while the others end more bluntly. A few dissepiments are discernible where the wall is especially thick, and a row of dissepiments form the inner edge of the calicular wall. The central area is entirely empty except for an occasional section of an irregular portion of a tabula and a filling of crystalline matrix.

A second section (Pl. V, Fig. 12 b,) has a diameter of 12.3 mm and is taken almost entirely between the tabulae, though the section of one of them cuts through the center. A few blunt septa appear in the edge of the wall at one point.

A third section (Pl. V, Fig. 12 c,) has a diameter of about 16 mm and shows a much thinner wall with the blunt septa projecting beyond it. In a number of cases,

these septa are seen to continue for some distance by a series of dots which suggest a spiniform character of the septal continuation on the surface of the tabula.

A longitudinal section (Pl. V, Fig. 13. Cat. 1616) shows the tabulae to be very numerous, close-set, mostly extending horizontally across the corallum but occasionally anastomosing. There are from 15 to 18 tabulae in one c m, but individually the width apart varies greatly. On the surface of many of them are seen vertical spines which are the sections of the septal continuation.

HORIZON AND LOCALITY: In the Lojoping Series of the Sintan shales, Lower Silurian of Lojoping, Ichang District, Hupeh Province. Collected by Hsieh & Chao. Locality 826. Cat. 1616—1622.

Amplexus chaoi Grabau

Plate, V Fig. 14 a-d.

1925. *Cyathophyllum chaoi* Grabau, Summary of the Faunas of the Sintan Shale. Bull. Geol. Survey China, No. 7 p. 79, Pl. III, fig. 3.

The holotype of *Cyathophyllum chaoi* has been sectioned and proved to have an amplexoid structure. The diameter of the calyx which is essentially the diameter of the specimen throughout the preserved part is 24 mm, while the preserved depth of the calyx is 10 mm which is apparently the original depth, since there is very little indication of injury to the calicinal rim. This has a thickness of 4 mm and is characterized by 36 septa. The two principal septa are slightly differentiated in the calyx. One of them slightly depressed in the top, projects into the floor for a short distance flanked by 2 slightly less projecting septa. This may be the counter with the two counter laterals. On the opposite side is apparently the cardinal, which projects in a slightly knob-like form on the inside rim of the calyx. Between these 2 major septa there are 17 septa on each side, of equal strength and size and apparently representing the alars and the secondaries. Between the grooves corresponding to each 2 of these is an additional groove indicating the incipient development of tertiary septa, though these are hardly visible in the calyx, but are indicated in the section by small spine-like projections. The transverse section (Fig. 14 b) shows the septa continuing inward for a maximum of 6 mm—that is, some at least project a little more than half way to the center. Others are shorter. They are thin and somewhat flexuous except at the epitheca where they broaden, more or less abruptly. The principal septa are not differentiated from the others in any way. Sometimes the tertiary septa are mere spines or scarcely visible at all. In other cases, they may be half the length of the secondaries to which they are then joined. One of the septa, slightly more thickened at the inner end, has a tertiary septum on each side joining it.

This may be the counter-septum and it is also one of the longest of the series. Opposite it, is a long slender septum which in that case represents the cardinal. There are no dissepiments, interspaces and center being empty except for the matrix of crystalline calcite and the accidental section of a tabula of irregular surface. The tabulae, as shown in longitudinal section, comprise a marginal zone between the septa, in which they slightly slope downwards, and the central zone where they are much more irregular, often discontinuous and coarsely vesiculose. Even in the marginal zone, there is much irregularity in the distance apart, but 11 occupy an interval of 1 cm. Occasionally the sections show a continuation of the septa as low ridges on the tabulae to about $\frac{2}{3}$ the distance to the center, but such an extension is relatively uncommon.

Externally the most prominent features are the costal grooves with the rather flatly rounded intervening ridges, the whole more or less cancellated by growth-lines and faint wrinkles.

HORIZON AND LOCALITY: In the Lojoping Series of the Sintan Shale, especially the middle or *Yangtzeephyllum* Bed, (Formerly called *Pselophyllum* bed) 826 B, at Shamaoshan, 10 li North-East of Lojoping, Cat. 1623.

TABLE SHOWING THE DISTRIBUTION OF THE FAMILIES, SUB-FAMILIES, GENERA, SPECIES AND VARIETIES DESCRIBED, INCLUDING THOSE DESCRIBED IN FASCICLE I. (continued)

FAMILIES	Page	Silurian	Devonian	Dinan- tian	Carboniferous	Permian
		Lungma Sh. Hupeh Loping Ser. Hupeh Chientshui Szechuan Foreign	Mid.-Dev. Yunnan Lower Middle <i>Foreign</i>	Tournaisian Chonlukou (Visen) Kansu Taiyuan Series	Moukou Ser. Kansu Yanhokou Ser. Kansu Chihlia L. Foreign	Yangsing L. Hupeh Fengtien Kiangsi Chert L. Anhwei Wushan L. Hupeh Loping Ser. Kiangsi Changsing Chekiang Permian Yunnan Timor Jisuhongner L. Mongolia Foreign
15. <i>Lopholasma carbonarium</i> Grabau.....	43					x
Sub-Family TACHYLASMAINÆ Grabau.....	54					
Genus TACHYLASMA Grabau.....	34					x x
16. <i>Tachylasma cha</i> Grabau.....	35					x x
17. <i>Tachylasma elongatum</i> Grabau.....	37					x
18. <i>Tachylasma aster</i> Grabau.....	38					x x
19. <i>Tachylasma beyrichi</i> (Rothpletzj).....	55					
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EXPLANATION OF
PLATE I.

PLATE I.

Silurian (1) and Permian Corals

Genera *Petraia*, *Polycoelia*, *Gerthia*, *Plerophyllum* and *Tachylasma*.

(Drawn by K. C. Liu).

- Fig. 1. *Petraia indifferens* Pocta.page 8
Section of individual, figured by Pocta, Pl. 108, Fig. 11. Silurian of Bohemia.
- Fig. 2. *Polycoelia cylindrica* Grabau.....page 26
2a. Side view of a fragment natural size.
2b. View of the calyx showing the 4 principal septa $\times 4$. Jisuhonguer Limestone, (Permian), Mongolia, Cat. G. S. C. 1488 (See Pl. VI, Fig. 14 a. b.)
- Fig. 3. *Polycoelia longiseptata* Grabau.....page 26
3a. Side view of a typical specimen, natural size.
3b. Section of the same, enlarged $\times 4$.
Jisuhonguer Limestone, Mongolia. (Permian). Holotype. Cat. G.S.C. 1485 (See Pl. VI, Fig. 15).
- Fig. 4. *Gerthia* (?) *sulcata* (Hinde).....page 34
Copy of Hinde's figure, Pl. VIII A, Fig. 2 a, $\times 2 \frac{1}{2}$; Permian? of Australia.
- Fig. 5. *Plerophyllum australe* Hindepage 46
Copy of Hinde's figure. Pl. VIII A, Fig. 1 d., $\times 2 \frac{1}{2}$; Permian? of Australia.
- Fig. 6. *Plerophyllum australe* Hinde.....page 46
Copy of Hinde's figure. Pl. VIII A. Fig. 1 e., $\times 2 \frac{1}{2}$; Permian? of Australia.
- Fig. 7. *Tachylasma lopingense* Grabau.....page 60
7a, Alar view of the Holotype $\times 1$.
7b, The same enlarged $\times 3$; 7c, Cardinal view of the same $\times 3$. 7d, Calicinal view of the same $\times 3$.
Loping Formation, Kiangsi Province. G. S. C. Cat. 1551.
- Fig. 8. *Tachylasma lopingense* Grabau.....page 60
Section of a young individual $\times 3$. G.S.C. 1552. Same Horizon and Locality.
- Fig. 9. *Tachylasma lopingense* Grabau.....page 60
Calyx of a weathered specimen, showing double character of principal septa $\times 3$. Cat. G.S.C. 1553. Same Horizon and Locality.



PLATE I (Concluded)

- Fig. 10. *Tachylasma lopingense* Grabau.....page 60
A longitudinal section of another specimen enlarged $\times 2$. Cat. 1554.
Same horizon and locality.
- Fig. 11. *Tachylasma magnum* Grabau.....page 64
11a. The holotype, partly preserved, embedded in rock, natural size.
11b. Section of the holotype at the point marked $\times$ in Fig. 11a., $\times 2$.
11c. Thin section slightly higher than the preceding $\times 3$. 11d. Thin section, about 5 mm above c. $\times 2$. 11e. Another thin section, about 5 mm higher $\times 2$. 11f. Polished section seen from below, and hence inverted, taken at the point marked. $\times 2$. 11g. Polished upper surface of the specimen showing section through calyx. This is about 7 mm above f.
Cherty Limestone; from the Lower Wushan Series. Shintan Rapids. Yangtze Gorge. Hupeh. Collected by Y.T. Chao. The age is probably Permian. Cat. G.S.C. 1555.
- Fig. 12. *Tachylasma magnum* Grabau.....page 64
12a, Thin section, of a large specimen taken about 35 mm below the calyx natural size. 12b, Oblique section through the calyx, natural size.
From the Permian Chert Limestone obtained from float 200 mm above the base of that limestone. Kien-yang Limestone, Kien-yang-Ping, Shing Shan-Hsien. Hupeh. Y.T. Chao collector.
- Fig. 13. *Tachylasma elongatum* Grabau.....page 69
13a, Thin section $\times 2$. 13b, Another thin section from the same individual $\times 2$.
Permian Chert Limestone, Peitze Kou. Soo-Sung-Hsien, Anhwei. C. C. Wang collector. Cat. 1557.

EXPLANATION OF
PLATE II.

PLATE II

Silurian, Viséen, Moscovian and Permian Corals

Genera. *Orthophyllum* (Sil.), *Barrandeophyllum* (Viséen), *Bradyphyllum*
(Moscovian) and *Plerophyllum* (Permian).

Drawn by K. C. Liu.

- | | | |
|---------|---|----|
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Side view of Gerth's type, from the Permian of Timor, Natural size.
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| Fig. 2. | <i>Plerophyllum weberi</i> Gerth.....page 73
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Timor. (Gerth Pl. III, Fig. 2). | 73 |
| Fig. 3. | <i>Orthophyllum hupehense</i> Grabau.....page 16
3a, Cardinal, 3b, lateral views of a typical specimen showing external
characters, natural size, Paratype, Cat. 1559. Same horizon and loca-
lity as fig. 6. | 16 |
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4a & 4b, 2 views of another smaller, flattened specimen. Natural size.
(Paratype) Cat. 1560, same horizon and locality as fig. 6. | 16 |
| Fig. 5. | <i>Orthophyllum hupehense</i> Grabau.....page 16
5a & 5b, 2 views of a specimen showing septal grooves, Natural size.
(Paratype) Cat. 1551, Same horizon and locality as Fig. 6. | 16 |
| Fig. 6. | <i>Orthophyllum hupehense</i> Grabau.....page 16
6a Section of a specimen showing characteristic septal arrangement $\times 5$.
6b. The same specimen, sectioned through the calyx $\times 5$. Cat, 1562.
(Holotype)
All the specimens Figs. 3-6 Lungma shale, 350 m. above the base of
Sintan Shale Lower Silurian. Lojoping, Ichang District, Hupeh.
Collected by Y. T. Chao & C. Y. Hsieh. Locality 824. | 16 |
| Fig. 7. | <i>Orthophyllum lojopingense</i> Grabau.....page 17
7a Lateral view of a corallum representing the holotype from which the
section was made $\times 1$. 7b section of the same, showing the arrange-
ment of septa $\times 5$.
Lungma Shale, Lower Silurian, Lojoping, Ichang, Hupeh Province.
Collected by Y. T. Chao & C. Y. Hsieh, Locality 826. Cat. 1563. | 17 |
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Longitudinal section of a specimen $\times 4 \frac{1}{2}$. (Paratype). Silurian,
Lungma Shale, Lojoping, Ichang, Hupeh, Locality 824, Collected by
Chao & Hsieh. Cat. 1564. | 16 |



PLATE II (Continued)

- Fig. 9. *Orthophyllum hupehense* Grabau.....page 16
Transverse section of a specimen, through calyx $\times 3$. (Paratype)
Silurian, Lungma Shale. Lojoping, Ichang, Hupeh Province, collected
by Chao & Hsieh, Locality 824, Cat. 1565.
- Fig. 10. *Orthophyllum hupehense* Grabau.....page 16
Section of the small end of a specimen, enlarged $\times 5$. (Paratype)
Silurian, Lungma Shale, Lojoping. Ichang, Hupeh Province. Cat.
1566.
- Fig. 11. *Bradyphyllum bellicostatum* Grabau.....page 37
Holotype. 11a, Cardinal view of a portion of a corallum cut at both
ends, enlarged $\times 3$. 11b, Section of the larger cut end, showing
septal arrangement, enlarged $\times 3$. 11c, View of the smaller cut end,
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sections of the same individual $\times 3$. Moukou Formation (Moscovian)
Moukou, Fu-I-Hsien, Kansu, P. L. Yuan. Coll. Locality 510. Cat.
1567.
- Fig. 12. *Bradyphyllum bellicostatum* Grabau.....page 37
12a Alar view of a specimen, cut at both ends, enlarged $\times 2$. 12b, View
of the polished upper end of the specimen showing cardinal & counter
fossulae $\times 3$. 12c, View of the lower end of the same reversed $\times 3$.
(Paratype)
Moukou Limestone (Moscovian), Moukou, Fu-I-Hsien, Kansu. P. L.
Yuan. Coll. Locality 510. Cat. 1568.
- Fig. 13. *Bradyphyllum bellicostatum* Grabau.....page 37
Longitudinal section of a specimen $\times 2$. (Paratype). Same horizon &
Locality as preceding. Cat. 1569.
- Fig. 14. *Bradyphyllum bellicostatum* Grabau.page 37
Alar view of a specimen, natural size (Paratype). Same horizon and
locality as preceding. Cat. 1570.
- Fig. 15. *Bradyphyllum bellicostatum* Grabau.....page 37
A somewhat smaller specimen, showing cardinal septum situated on
the side; natural size. (Paratype). Same horizon and locality. Cat.
1571.
- Fig. 16. *Bradyphyllum bellicostatum* Grabau.....page 37
Alar view of another characteristic specimen, natural size. (Para-
type). Same horizon and locality as preceding. Cat. 1572.
- Fig. 17. *Bradyphyllum bellicostatum* Grabau.....page 37
View of the calyx of a specimen $\times 3$. (Paratype) Same horizon and
locality. Cat. 1573.

PLATE II (Concluded)

- Fig. 18. *Bradyphyllum bellicostatum* Grabau.....page 37
 18a-18c, 3 successive thin sections of the same individual, showing changes in the arrangement of the septa, enlarged $\times 3$. (Paratype). Same horizon and locality as preceding. Cat. 1574.
- Fig. 19. *Barrandeophyllum choniukounense* Grabau.....page 88
 19a Lateral view of the holotype before sectioning, natural size; 19b, Polished section of the same 6 mm above the base $\times 3$; 19c, Polished section about 1 mm higher seen from below, hence reversed $\times 3$, 19d, Polished section 4 mm above c, $\times 3$; 19e, view of the calyx $\times 2$. Choniukou Formation (Viséen) Basal part. Wuwei Hsien, Kansu. P. L. Yuan collector, Cat. 1575.
- Fig. 20. *Bradyphyllum bellicostatum* Grabau.....page 37
 Section of young individual with 22 undifferentiated septa and the center a mass of stereoplasm, diameter 7 mm. (Paratype). Moukou formation (Moscovian), Fu-I-Hsien, Kansu, P. L. Yuan, Coll. Cat. 1587.

EXPLANATION OF
PLATE III.

PLATE III

Viséen, Moscovian, and Permian Corals

Genera: *Barrandeophyllum* (Viséen), *Sockkineophyllum* & *Rossophyllum* (Moscovian)
and *Timorphyllum* Permian.

(Drawn by K. C. Liu)

- Fig. 1. *Barrandeophyllum disjunctum* Grabau.....page 93
1a, Photograph of the holotype before it was sectioned, natural size, 1b, Section of the same 9 mm above the base, showing nature of inner wall $\times 3$. 1c, Section several mm higher seen from below and hence reversed, showing separation of wall and septa on one side $\times 3$. 1d, a thin section 12.5 mm above c, showing strong separation of inner wall $\times 3$. 1e, Polished surface just above section 1d. (reversed).
- Choniukou Formation (Viséen) Kankou, Wu-Wei-Hsien, Kansu. P. L. Yuan collector, Cat. 1578.
- Fig. 2. *Sochkineophyllum kansuense* Grabau.....page 79
2a-2e A successive series of thin sections of the holotype, showing the arrangement of septa. Enlarged $\times 3$. Yanghukou Formation (Moscovian) Yanghukou Shan-Tan-Hsien, Kansu, P. L. Yuan collector. Cat. 1579.
- Fig. 3. *Rossophyllum kansuense* Grabau.....page 106
3a-3c Calicinal, lateral and cardinal views of a typical specimen natural size, Moukou Limestone (Moscovian) Moukou, Fu-I-Hsien, Kansu. P. L. Yuan collector, Cat. 1580.
- Fig. 4. *Rossophyllum kansuense* Grabau.....page 106
4a-4b Calicinal and lateral views of a somewhat larger specimen, natural size. Cat. 1581. Same horizon & locality as preceding.
- Fig. 5. *Rossophyllum kansuense* Grabau.....page 106
The calyx of a somewhat imperfect specimen, showing a median columella $\times 3$. Cat. 1582. Same horizon and locality as preceding.
- Fig. 6. *Rossophyllum kansuense* Grabau.....page 106
6a-6b, 2 successive sections, both seen from below and hence reversed, showing the slender counter-septum and its incipient pseudo-columella $\times 3$. 6c Section through the calyx of the same individual $\times 3$. Same horizon & locality. Cat. 1583.
- Fig. 7. *Timorphyllum wanneri* Gerth var. *variabilis* Gerth.....page 109
7a. Section of the upper end of a fragment 2 cm. long showing principal septa. x=columella, y=section of a slightly arched tabulum $\times 2$.
7b. Section at lower end of same specimen showing early stage of septal development $\times 2$. After Gerth p 71, fig. 3, reversed and relettered. Permian of Timor.
aa=alar septa; c=cardinal septum; cl=counter laterals; ct=counter septum.

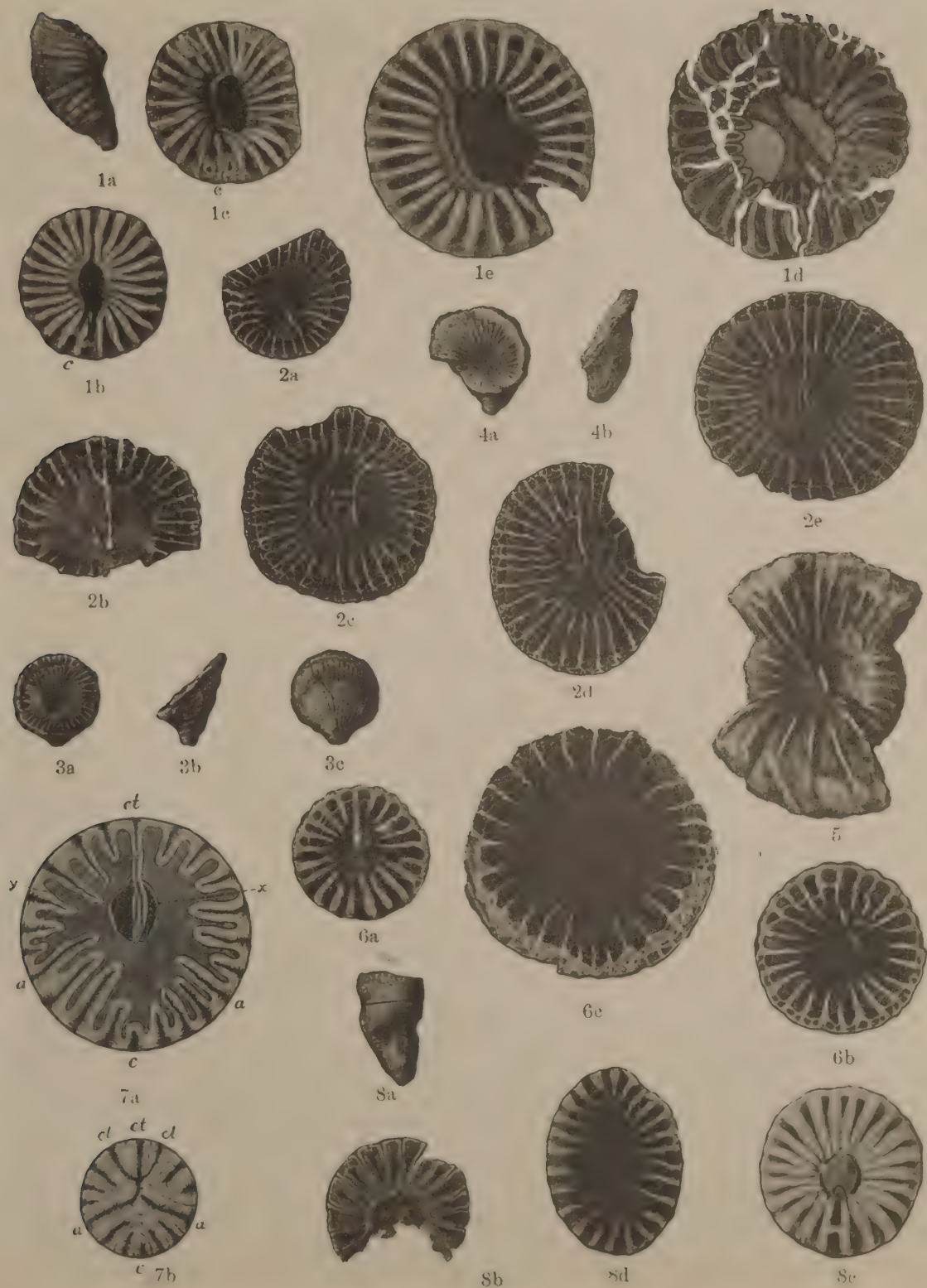


PLATE III (concluded)

- Fig. 8. *Barrandeophyllum compressum* Grabau.....page 90
- 8a. A side view of the corallum, cut at both ends natural size. 8b, Thin section near the base, showing origin of the wall by union of septal ends $\times 5$. 8c, Median section of the same, showing the thick-walled inner tube, enlarged $\times 5$. 8d, Section below the calyx showing the compressed character and the nature & disposition of the septa $\times 3$. Choniukou Formation (Viséen) Lower part, Wu-Wei-Hsien, Kansu. P. L. Yuan collector. Cat. 1576.

EXPLANATION OF
PLATE IV.

PLATE IV

Viséen, Moscovian, and Permian Corals

Genera: *Hapsiphyllum* (Viséen & Moscovian), *Meniscophyllum* (Moscovian) and *Sinophyllum* (Permian). (aa=alar septa; c Cardinal septum; ct=counter septum)

(Drawn by K. C. Liu)

- Fig. 1. *Sinophyllum pendulum* Grabau.....Page 100
 1a Thin section of the lower part of the corallum showing primitive quadripartite arrangement of septa $\times 3$. 1b & 1c, Thin sections of an intermediate portion of the same corallum, showing an open space between the inner wall formed by the junction of the septal ends and the pseudocolumella and the structure of the latter $\times 3$. 1d, Polished section of the same corallum seen from below and hence reversed; the space between the inner wall and pseudo-columella is pronounced. $\times 3$. 1e, Section through the lower part of the calyx 4.4 mm above d, showing the penduliform pseudo-columella and the radial septa $\times 3$.
 Mid Permian Loping coal series. Loping Kiangsi province. Cat. G. S. C. 1585.
- Fig. 2. *Sinophyllum pendulum* Grabau.....Page 100
 2a Alar view of a specimen cut at both ends showing the disposition of the septal grooves, $\times 2$. 2b, Section 10 mm above the base of the fragment showing the inner wall $\times 2$. 2c, Polished section about 1 mm higher, seen from below, and hence reversed, showing the free ends of the septa $\times 2$. 2d, Top of the fragment shown in 2a and 4.8 mm above c, $\times 2$. The pseudo-columella is now free from the counter septum and the septa are all radial. The same horizon and locality as preceding. Cat. 1586.
- Fig. 3. *Sinophyllum pendulum* Grabau.....Page 100
 3a. Side view of a fragment, with the columella projecting freely in the calyx. Natural size. 3b. The calyx enlarged $\times 3$, somewhat crushed, but showing the freely tapering pseudo-columella, with the center weathered so as to appear a hollow tube, the whole resembling the median tube of *Permia*.
 3c. Section through the middle of the corallum showing the penduliform pseudo-columella and the septa, joined by their thickened ends $\times 5$.
 The same horizon and locality as the preceding, Cat. G.S.C. 1584.
- Fig. 4. *Meniscophyllum kansuense* Grabau.....page 100
 4a A thin section of a very young stage, showing the branching character of the septa $\times 5$. 4b, Section about 10 mm above base, showing a long cardinal septum and other septa united by median stereoplasm $\times 5$. 4c, Section c, a polished surface, a short distance above b seen



PLATE IV (Continued)

from below and hence reversed. The cardinal septum is free as are also the cardinal secondaries $\times 5$. *4d*, Section *c'* through the calyx, about 1.3 mm above *c*. $\times 5$, showing the radial character of the septum free from stereoplasm. *4e*, Another section (*d'*) through the upper part of the calyx, showing carina-like character of the septa. Within the calyx is a section of the young stage of another corallum, probably of this species. Yanghukou Formation (Moscovian), Yang-Hu-Kou, Shan-Tan-Hsien, Kansu. P. L. Yuan, collector. Cat. 1590, holotype.

Fig. 5. *Hapsiphyllum yuani* Grabau.....page 120

5a Alar view of the holotype; natural size. *5b*, Section *b*, 2.5 mm above the base $\times 3$. *5c* Section *c* Polished section *a* short distance above *b*, seen from below and hence reversed $\times 3$. *5d*, Polished section 2.5 to 3.7 mm above *c*, $\times 3$. *5e* Another polished section a short distance higher, seen from below, and hence reversed. The counter septum is thickened bulb-like, the other septa largely joined by their thickened ends $\times 3$. *5f*, Section through the calyx 4.2 mm above *e* the septa are radial, $\times 3$, Yanghukou Formation (Moscovian), Yang-Hu-Ku, Shan-Tan-Hsien, Kansu, P. L. Yuan collector. Cat. 1591,

Fig. 6. *Hapsiphyllum altiseptum* Grabau.....page 123

6a & *6b*, Two views of the holotype, natural size. *6c*, Calyx of the same, natural size. *6d*, Basal portion of the same after sectioning, seen from the cardinal side enlarged $\times 3$. *6e*, Section *a*, the upper surface of the fragment shown in *6d* and 7.4 mm above the base, showing the strong development of the *Hapsiphyllum* wall, and the cardinal septum tied to it by dissepiment $\times 3$. *6f*, Section *b* about 2 mm higher. Polished surface seen from below and hence reversed. The strong counter septum is particularly marked. *6g*, The calyx shown in Fig. *6c* and enlarged $\times 3$, 9 mm above *f*. The strong counter and thickened alar septa are shown and the well-formed inner wall of key-hole shape.

Choniukou Formation (Viséen) Choniukou, Wu-Wei-Hsien, Kansu. P. L. Yuan collector. Cat. 1592.

Fig. 7. *Hapsiphyllum moukouense* Grabau.....page 124

7a, A small specimen, natural size, holotype. *6b*, Lateral view of the same enlarged $\times 2$, *7c*, The calyx of the same enlarged $\times 3$. Moukou Formation (Moscovian) Moukou, Fu-I-Hsien, Kansu. P. L. Yuan collector. Cat. 1594.

Fig. 8. *Hapsiphyllum moukouense* Grabau.....page 124

8a Side view of a specimen slightly worn at the calyx showing septa and dissepiments $\times 2$, *8b*, calyx of the same $\times 5$. Same formation and locality as preceding. Cat. 1595.

PLATE IV (*Concluded*)

- Fig. 9. *Hapsiphyllum moukouense* Grabaupage 124
9a Section of the young stage of another individual enlarged $\times 5$. 9b,
A later section of the same individual $\times 5$ Same horizon & locality
as preceding. Cat. 1596.
- Fig. 10. *Hapsiphyllum moukouense* Grabau.....page 124
Longitudinal section of another individual, showing the junction of
the thickened septa in the center $\times 5$. Same horizon & locality as
preceding. Cat. 1597.

EXPLANATION OF

PLATE V.

PLATE V.

Silurian, Carboniferous and Permian corals.

Genera: *Amplexus* (Sil.), *Hapsiphyllum* (Moscovian), *Sinophyllum* (U. Carb.), and *Allotropiophyllum* (Up. Carb.-Perm.)

(Drawn by K. C. Liu).

- Fig. 1. *Allotropiophyllum sinense* Grabau.....Page 130
Side view of strongly spinose individuals with abruptly curved basal part $\times 3$. Chihhsia Limestone, Chihhsia-Shan Nanking Region, Cat. 1604. paratype.
- Fig. 2. *Allotropiophyllum sinense* Grabau.....page 130
View of the cardinal side and calyx of another specimen, showing the flat central area and septa $\times 2$. Same horizon and locality as preceding. Cat. 1602. paratype.
- Fig. 3. *Allotropiophyllum sinense* Grabau.....page 130
An imperfect specimen, showing the depth of the calyx $\times 2$. Same horizon & locality. Cat. 1606. paratype.
- Fig. 4. *Allotropiophyllum sinense* Grabau (Holotype).....page 130
4a, Section of a very young stage, showing primary and few secondary septa, reversed $\times 5$. 4b, Section 4.7 mm above a. The cardinal gap is bridged and 2 cardinal secondaries are developed, $\times 5$. 4c, Section about 1 mm above b, polished section seen from below and hence reversed $\times 5$. 4d, Polished section 5.3 mm above c $\times 5$. 4e, Polished section about 1 mm higher or 8.5 mm below calyx, reversed $\times 5$. Same horizon & locality. Cat. 1600.
- Fig. 5. *Allotropiophyllum sinense* Grabau.....page 130
5a Thin section of another specimen nearly 10 mm above the base $\times 5$. 5b Thin section of the same specimen about 7 mm below the calyx $\times 5$. Same horizon & locality. Cat. 1593. paratype.
- Fig. 6. *Allotropiophyllum sinense* var. *heteroseptatum* Grabau.....page 136
6a A thin section of the holotype $\times 5$, showing 3 cardinal secondaries and long cardinal. 6b, Section of the same individual somewhat higher, showing well developed tertiaries and shortened cardinal septum $\times 5$. 6c, A section still higher, showing the inner wall more or less closed $\times 5$. The cardinal quadrants have 3 and the counter quadrants 7 septa.
Yanghsing Limestone. (Upper Carb. or L. Perm.) Fuchikou, Yang-Hsing-Hsien, East Hupeh. Collected by Liu & Hsieh. Cat. 1607.
- Fig. 7. *Sinophyllum multiseptum* Grabau.....page 10
Thin section of the holotype $\times 5$, showing the well developed tertiary septa and the character of the inner wall and penduliform pseudocolumella, Yanghsing Limestone. (Upper Carb. or L. Perm.) Fuchikou Yang-Hsing-Hsien, East Hupeh. Cat. 1608.



PLATE V (continued)

- Fig. 8. *Amplexus lojopingensis* Grabau.....page 143
Side view of a typical specimen, natural size. (Silurian) Lojoping Series. Sintan Shale, Ichang District, Hupeh. Collected by Hsieh & Chao. Cat. 1621.
- Fig. 9. *Amplexus lojopingensis* Grabau.....page 143
Young individual, natural size, showing early development of tabulae and tetrameral arrangement of septa. Same horizon & locality as preceding. Cat. 1618.
- Fig. 10. *Amplexus lojopingensis* Grabau.....page 143
Another specimen of irregular growth, natural size. Same horizon and locality. Cat. 1619.
- Fig. 11. *Amplexus lojopingensis* Grabau.....page 143
Another specimen showing successive calicinal constrictions, natural size. Same horizon & locality. Cat. 1620.
- Fig. 12. *Amplexus lojopingensis* Grabau.....page 143
12a to 12c. Three successive thin sections of another individual, natural size. Same horizon and locality. Cat. 1516.
- Fig. 13. *Amplexus lojopingensis* Grabau.....page 143
Thin longitudinal section of another individual showing crowded tabulae. Same horizon & locality. Cat. 1616.
- Fig. 14. *Amplexus chaoi* Grabau.....page 144
14a View of the calyx of the holotype. Natural size. 14 b, Thin section of the same, some distance below the calyx, natural size. 14c Sectional view of same $\times 1$. 14d, Thin longitudinal section of a portion of the same showing the tabulae; natural size.
Lojoping Series, Sintan shale, Ichang District, Hupeh. Collected by Hsieh & Chao. Cat. 1623.
- Fig. 15. *Hapsiphyllum elegantulum* Grabau.....page 127
Cardinal view of a small specimen, showing the strongly developed septal grooves and rapid enlargement $\times 3$. The attachment scar shows on the lower left hand side. Moukou Formation Moukou Limestone (Moscovian). Moukou, Fu-I-Hsien, Kansu. Locality 510 Cat. 1636. Collected by P. L. Yuan.
- Fig. 16. *Hapsiphyllum elegantulum* Grabau.....page 127
Cardinal view of another individual with large attachment scar on the right side $\times 2$. Same horizon & locality, Cat. 1634.
- Fig. 17. *Hapsiphyllum elegantulum* Grabau.....page 127
Alar view of a somewhat larger individual, the scar on the lower side, $\times 2$. Same horizon & locality; Cat. 1635.

PLATE V (concluded)

- Fig. 18. *Hapsiphyllum elegantulum* Grabau.....page 127
18a Section of an individual 4.9 mm above the base $\times 5$. The cardinal gap is closed by stereoplasm and the central area opens laterally. This in an individual imperfection. 18b Another polished section about 1 mm higher $\times 5$, Reversed. Same horizon & locality Cat 1628.
- Fig. 19. *Hapsiphyllum elegantulum* Grabau.....page 127
A thin section of another individual near the calyx showing a number of free septa $\times 5$. Same horizon & locality. Cat. 1632.

**EXPLANATION OF
PLATE VI.**

PLATE VI

Silurian, Devonian, Viséen, Moscovian and Permian Corals

Genera: *Petraia*, & *Alleyinia* (Sil.) *Oligophyllum* (Dev.), *Barrandeophyllum* and *Hapsiphyllum* (Viséen), *Brachyphyllum* (Moscovian).

(Drawn by K. C. Liu).

- Fig. 1. *Petraia* sp 1.....page 10
1a Alar, 1b basal views of internal mold, showing the arrangement of the septa here represented by grooves. $\times 5$. The cardinal quadrants are greatly accelerated. Lungma Shale (Silurian) 350 mm above base of Sintan Shale, Lojoping, Ichang, Hupeh. Collected by Hsieh & Chao. Cat. 1639.
- Fig. 2. *Petraia* sp 1.....page 10
A younger individual of the same species, 2a alar, 2b basal views. The counter quadrants are accelerated. Same horizon & locality. Cat. 1640.
- Fig. 3. *Petraia* sp. 2.....page 13
3a Cardinal, 3b basal views of an internal mold showing the impressions of spiniform septa, $\times 5$. Same horizon & locality as preceding. Cat. 1641.
- Fig. 4. *Bradyphyllum obscurum* Grabau.....page 41
4a Lateral view of the holotype, natural size. 4b, Section through the lower part of the same, $\times 3$. 4c, Section several mm higher, $\times 3$, reversed. 4d, Section 3.5 to 9 mm higher, $\times 3$.
Moukou formation (Moscovian) Moukou, Fu-I-Hsien, Kansu, P. L. Yuan Coll. Cat. 1589.
- Fig. 5. *Bradyphyllum obscurum* Grabau.....page 41
5a Polished section of another individual $\times 3$, 5.6 mm above base. 5b Polished section of the same several mm higher (reversed) $\times 3$. Same horizon and locality as preceding. Cat. 1609.
- Fig. 6. *Hapsiphyllum magnolacunum* Grabau.....page 129
6a Side view of the lower part of the holotype from which the sections are made $\times 2$. 6b The upper section surface of the preceding enlarged $\times 5$, showing the inner tube closed by stereoplasm. 6c Thin section several mm higher. Choniukou formation, Viséen. Locality 547. Kansu. Cat. 1643.
- Fig. 7. *Oligophyllum permirum* Pocta.....page 50
Copy of the enlarged section figured by Pocta (Pl. 108, Fig. 20.) Lower Middle Devonian of Bohemia.
- Fig. 8. *Oligophyllum quinquesepatum* Pocta.....page 50
Copy of the enlarged section figured by Pocta (Pl. 108, Fig 17) Lower-Middle Devonian of Bohemia.

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Grabau: Palæozoic Corals of China II.

Plate VI



PLATE VI (Concluded)

- Fig. 9. *Oligophyllum quinqueseptatum* Pocta.....page 50
Copy of the enlarged section figured by Pocta (Pl. 108, Fig. 18.)
Lower Middle Devonian of Bohemia.
- Fig. 10. *Alleynia perfecta* Pocta.....page 84
Copy of the enlarged section of the young figured by Pocta (Pl. 108,
Fig. 1.) Silurian, E. 2, of Bohemia.
- Fig. 11. *Alleynia perfecta*, Pocta.....page 84
Copy of the enlarged section of the adult figured by Pocta (Pl. 108,
Fig. 2.) Silurian, E₂ of Bohemia.
- Fig. 12. *Barrandeophyllum compressum* Grabau.....page 92
12a Alar view of a fragment polished at both ends $\times 3$. 12b View of
the top of the same $\times 3$. 12c Base of upper part below the calyx,
about 3 mm higher, reversed $\times 3$. Chóniukou Formation (Viséen),
upper middle part. Wu-Wei-Hsien, Kansu, P. L. Yuan collector. Cat.
1577.
- Fig. 13. *Tachylasma emaceratum* Grabau.....page 76
13a View of the weathered end of the holotype $\times 2$, 13b Section
about 10 mm lower down. $\times 2$. 13c Section 3, 4 mm below b. Seen
from below and hence reversed. 13d Section 4 Section a short distance
below section 3. Permian Chert Limestone. Yang-Kong-Chow,
Kuei-Chih-Hsien, Anhwei. Collected by Yih & Li. Cat. 1558.
- Fig. 14. *Polycoelia cylindrica* Grabau.....page 26
14a Side view of a fragment of a corallum before sectioning. Nat.
size. 14b, Thin section through middle of same specimen $\times 4$ (No.
466)
Permian Jisuhonguer limestone, Mongolia Coll. F. K. Morris, Cat.
G. S. C. 1487.
- Fig. 15. *Polycoelia longiseptata* Grabau.....page 26
Section of specimen Pl. I Fig. 3a at c $\times 4$, Cat. 1484, No. 462c,
Permian, Jisuhonguer limestone (1190) F. K. Morris Coll.

THE GEOLOGICAL SURVEY OF CHINA
PALÆONTOLOGIA SINICA

中國古生物誌

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The detailed description of the large collection of prehistoric ceramics and other artifacts will be entrusted to a number of specialists. Details about the names of the different authors and the

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二疊紀與其上之紡錘虫層及蕉葉貝層 (Lyttonia bed) 成連續之停積。此一石灰岩系富含燧石結核，共厚約五百餘公尺，在揚子江流域分佈甚廣，西起四川東至江浙幾無處無之。惟上部之蕉葉貝層每變爲一煤系，如江西之樂平浙江之長興是也。於此燧石石灰岩下部之珊瑚層（即棲霞石灰岩）內，葛氏鑑定有下列二種：

22. *Allotriophyllum sinense* Gr. (卷一六四頁第一版，二二至二三圖；卷二一三〇頁第五版，一至五圖)
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- 燧石石灰岩之中上部產左列諸種珊瑚化石：
24. *Tachyasma cha* Gr. (一三五頁第一版第二圖)
 25. *Tachyasma aster* Gr. (一三八頁第一版，三至四圖)
 26. *Tachyasma lopingense* Gr. (一六〇頁第一版第七至一〇圖)
 27. *Tachyasma magnum* Gr. (一六四頁第一版，一至一二圖)
 28. *Tachyasma elongata* Gr. (一三七頁第一版第十三圖；二六九頁第一版第一三圖)
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 31. *Sinophyllum multiseptum* Gr. (一一〇五頁第五版七圖)
- 於內蒙古幾徐杭格爾之二疊紀內石灰岩，葛利普博士鑑定有左列二種珊瑚化石：
32. *Polycocelia cylindrica* Gr. (二二六頁第一版第二圖，第六版第一四圖)
 33. *Polycocelia longiseptata* Gr. (二二二頁第一版第三圖，第六版第十五圖)

8. *Barrandeophyllum compressum* Gr. (卷二九〇頁, 第三版, 第八圖, 第六版, 第十二圖)
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本溪系

12. *Bradyphyllum bellicostatum* Gr. (卷二二七頁, 第二版, 第二至一四, 一六至一七圖)
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19. *Meniscophyllum kansuense* Gr. (卷二一四〇頁, 第四版, 第四圖)

太原系

20. *Lopholasma carbonaria* Gr. (卷一四三頁, 第二版, 第五a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z, aa, ab, ac, ad, ae, af, ag, ah, ai, aj, ak, al, am, an, ao, ap, aq, ar, as, at, au, av, aw, ax, ay, az, ba, bb, bc, bd, be, bf, bg, bh, bi, bj, bk, bl, bm, bn, bo, bp, bq, br, bs, bt, bu, bv, bw, bx, by, bz, ca, cb, cc, cd, ce, cf, cg, ch, ci, cj, ck, cl, cm, cn, co, cp, cq, cr, cs, ct, cu, cv, cw, cx, cy, cz, da, db, dc, dd, de, df, dg, dh, di, dj, dk, dl, dm, dn, do, dp, dq, dr, ds, dt, du, dv, dw, dx, dy, dz, ea, eb, ec, ed, ee, ef, eg, eh, ei, ej, ek, el, em, en, eo, ep, eq, er, es, et, eu, ev, ew, ex, ey, ez, fa, fb, fc, fd, fe, ff, fg, fh, fi, fj, fk, fl, fm, fn, fo, fp, fq, fr, fs, ft, fu, fv, fw, fx, fy, fz, ga, gb, gc, gd, ge, gf, gg, gh, gi, gj, gk, gl, gm, gn, go, gp, gq, gr, gs, gt, gu, gv, gw, gx, gy, gz, ha, hb, hc, hd, he, hf, hg, hh, hi, hj, hk, hl, hm, hn, ho, hp, hq, hr, hs, ht, hu, hv, hw, hx, hy, hz, ia, ib, ic, id, ie, if, ig, ih, ii, ij, ik, il, im, in, io, ip, iq, ir, is, it, iu, iv, iw, ix, iy, iz, ja, jb, jc, jd, je, jf, jg, jh, ji, jj, jk, jl, jm, jn, jo, jp, jq, jr, js, jt, ju, jv, jw, jx, jy, jz, ka, kb, kc, kd, ke, kf, kg, kh, ki, kj, kk, kl, km, kn, ko, kp, kq, kr, ks, kt, ku, kv, kw, kx, ky, kz, la, lb, lc, ld, le, lf, lg, lh, li, lj, lk, ll, lm, ln, lo, lp, lq, lr, ls, lt, lu, lv, lw, lx, ly, lz, ma, mb, mc, md, me, mf, mg, mh, mi, mj, mk, ml, mm, mn, mo, mp, mq, mr, ms, mt, mu, mv, mw, mx, my, mz, na, nb, nc, nd, ne, nf, ng, nh, ni, nj, nk, nl, nm, nn, no, np, nq, nr, ns, nt, nu, nv, nw, nx, ny, nz, oa, ob, oc, od, oe, of, og, oh, oi, oj, ok, ol, om, on, oo, op, oq, or, os, ot, ou, ov, ow, ox, oy, oz, pa, pb, pc, pd, pe, pf, pg, ph, pi, pj, pk, pl, pm, pn, po, pp, pq, pr, ps, pt, pu, pv, pw, px, py, pz, qa, qb, qc, qd, qe, qf, qg, qh, qi, qj, qk, ql, qm, qn, qo, qp, qq, qr, qs, qt, qu, qv, qw, qx, qy, qz, ra, rb, rc, rd, re, rf, rg, rh, ri, rj, rk, rl, rm, rn, ro, rp, rq, rr, rs, rt, ru, rv, rw, rx, ry, rz, sa, sb, sc, sd, se, sf, sg, sh, si, sj, sk, sl, sm, sn, so, sp, sq, sr, ss, st, su, sv, sw, sx, sy, sz, ta, tb, tc, td, te, tf, tg, th, ti, tj, tk, tl, tm, tn, to, tp, tq, tr, ts, tt, tu, tv, tw, tx, ty, tz, ua, ub, uc, ud, ue, uf, ug, uh, ui, uj, uk, ul, um, un, uo, up, uq, ur, us, ut, uu, uv, uw, ux, uy, uz, va, vb, vc, vd, ve, vf, vg, vh, vi, vj, vk, vl, vm, vn, vo, vp, vq, vr, vs, vt, vu, vv, vw, vx, vy, vz, wa, wb, wc, wd, we, wf, wg, wh, wi, wj, wk, wl, wm, wn, wo, wp, wq, wr, ws, wt, wu, wv, ww, wx, wy, wz, xa, xb, xc, xd, xe, xf, xg, xh, xi, xj, xk, xl, xm, xn, xo, xp, xq, xr, xs, xt, xu, xv, xw, xx, xy, xz, ya, yb, yc, yd, ye, yf, yg, yh, yi, yj, yk, yl, ym, yn, yo, yp, yq, yr, ys, yt, yu, yv, yw, yx, yy, yz, za, zb, zc, zd, ze, zf, zg, zh, zi, zj, zk, zl, zm, zn, zo, zp, zq, zr, zs, zt, zu, zv, zw, zx, zy, zz)
21. *Lophocarinophyllum acanthiseptum* Gr. (卷一五一頁, 第一版, 第六a, c, e, g, i, k, m, o, q, s, u, w, y, aa, ab, ac, ad, ae, af, ag, ah, ai, aj, ak, al, am, an, ao, ap, aq, ar, as, at, au, av, aw, ax, ay, az, ba, bb, bc, bd, be, bf, bg, bh, bi, bj, bk, bl, bm, bn, bo, bp, bq, br, bs, bt, bu, bv, bw, bx, by, bz, ca, cb, cc, cd, ce, cf, cg, ch, ci, cj, ck, cl, cm, cn, co, cp, cq, cr, cs, ct, cu, cv, cw, cx, cy, cz, da, db, dc, dd, de, df, dg, dh, di, dj, dk, dl, dm, dn, do, dp, dq, dr, ds, dt, du, dv, dw, dx, dy, dz, ea, eb, ec, ed, ee, ef, eg, eh, ei, ej, ek, el, em, en, eo, ep, eq, er, es, et, eu, ev, ew, ex, ey, ez, fa, fb, fc, fd, fe, ff, fg, fh, fi, fj, fk, fl, fm, fn, fo, fp, fq, fr, fs, ft, fu, fv, fw, fx, fy, fz, ga, gb, gc, gd, ge, gf, gg, gh, gi, gj, gk, gl, gm, gn, go, gp, gq, gr, gs, gt, gu, gv, gw, gx, gy, gz, ha, hb, hc, hd, he, hf, hg, hh, hi, hj, hk, hl, hm, hn, ho, hp, hq, hr, hs, ht, hu, hv, hw, hx, hy, hz, ia, ib, ic, id, ie, if, ig, ih, ii, ij, ik, il, im, in, io, ip, iq, ir, is, it, iu, iv, iw, ix, iy, iz, ja, jb, jc, jd, je, jf, jg, jh, ji, jj, jk, jl, jm, jn, jo, jp, jq, jr, js, jt, ju, jv, jw, jx, jy, jz, ka, kb, kc, kd, ke, kf, kg, kh, ki, kj, kk, kl, km, kn, ko, kp, kq, kr, ks, kt, ku, kv, kw, kx, ky, kz, la, lb, lc, ld, le, lf, lg, lh, li, lj, lk, ll, lm, ln, lo, lp, lq, lr, ls, lt, lu, lv, lw, lx, ly, lz, ma, mb, mc, md, me, mf, mg, mh, mi, mj, mk, ml, mm, mn, mo, mp, mq, mr, ms, mt, mu, mv, mw, mx, my, mz, na, nb, nc, nd, ne, nf, ng, nh, ni, nj, nk, nl, nm, nn, no, np, nq, nr, ns, nt, nu, nv, nw, nx, ny, nz, oa, ob, oc, od, oe, of, og, oh, oi, oj, ok, ol, om, on, oo, op, oq, or, os, ot, ou, ov, ow, ox, oy, oz, pa, pb, pc, pd, pe, pf, pg, ph, pi, pj, pk, pl, pm, pn, po, pp, pq, pr, ps, pt, pu, pv, pw, px, py, pz, qa, qb, qc, qd, qe, qf, qg, qh, qi, qj, qk, ql, qm, qn, qo, qp, qq, qr, qs, qt, qu, qv, qw, qx, qy, qz, ra, rb, rc, rd, re, rf, rg, rh, ri, rj, rk, rl, rm, rn, ro, rp, rq, rr, rs, rt, ru, rv, rw, rx, ry, rz, sa, sb, sc, sd, se, sf, sg, sh, si, sj, sk, sl, sm, sn, so, sp, sq, sr, ss, st, su, sv, sw, sx, sy, sz, ta, tb, tc, td, te, tf, tg, th, ti, tj, tk, tl, tm, tn, to, tp, tq, tr, ts, tt, tu, tv, tw, tx, ty, tz, ua, ub, uc, ud, ue, uf, ug, uh, ui, uj, uk, ul, um, un, uo, up, uq, ur, us, ut, uu, uv, uw, ux, uy, uz, va, vb, vc, vd, ve, vf, vg, vh, vi, vj, vk, vl, vm, vn, vo, vp, vq, vr, vs, vt, vu, vv, vw, vx, vy, vz, wa, wb, wc, wd, we, wf, wg, wh, wi, wj, wk, wl, wm, wn, wo, wp, wq, wr, ws, wt, wu, wv, ww, wx, wy, wz, xa, xb, xc, xd, xe, xf, xg, xh, xi, xj, xk, xl, xm, xn, xo, xp, xq, xr, xs, xt, xu, xv, xw, xx, xy, xz, ya, yb, yc, yd, ye, yf, yg, yh, yi, yj, yk, yl, ym, yn, yo, yp, yq, yr, ys, yt, yu, yv, yw, yx, yy, yz, za, zb, zc, zd, ze, zf, zg, zh, zi, zj, zk, zl, zm, zn, zo, zp, zq, zr, zs, zt, zu, zv, zw, zx, zy, zz)

揚子江流域之棲霞石灰岩前人多誤視為下石炭紀, 近就腕足類化石之研究始知其應屬於上石炭紀或下

中國古生代珊瑚化石卷二

葛利普著

於英文文中，葛利普博士對於諸種珊瑚之構造及其彼此之關係鉅論甚詳，無須重贅。惟葛氏採系統研究方法，而略於地層上之位置及分佈。茲爲讀者易於檢查起見，特簡述凡已經葛氏研究之珊瑚化石在我國地層中之位置及地理上之分佈如左。

趙亞曾附記

四射珊瑚首出現於奧陶紀，該時種類均屬單體，構造簡單。我國奧陶紀地層南北雖皆稱發達，但直至今日尙未有四射珊瑚化石之發見。僅於下奧陶紀地層中曾得有所謂古孟珊瑚 (Archaeocyathine) 者數種，惟其是否爲真正之珊瑚，仍不無疑問耳。

在湖北宜昌北八十里之羅惹坪，於志留紀新灘頁岩之下部，曾發見一極爲富豐之珊瑚動物羣，其已經葛氏研究者有左列各種。

1. *Petraia* sp. 1. (卷二，第一〇頁，第六版，第一及二圖)
2. *Petraia* sp. 2. (卷二，第一三頁，第六版，第三圖)
3. *Orthophyllum hupehense* Gr. (卷二，第一六頁，第二版，第三至六及八至十圖)
4. *Orthophyllum lojopingense* Gr. (卷二，第一七頁，第二版，第七圖)
5. *Amplexus chaoi* Gr. (卷二，第一四四頁，第五版，第十四圖)
6. *Amplexus lojopingensis* Gr. (卷二，第一四三頁，第五版，八至十三圖)
7. *Barrandeophyllum choninkouense* Gr. (卷二，第八八頁，第三版，第十九圖)

甘肅武威縣臭牛溝之下石炭紀地層中富產珊瑚化石，其已鑑定者有：

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THE NATIONAL GEOLOGICAL SURVEY OF CHINA

IN COOPERATION WITH

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THE GEOLOGICAL DEPARTMENT OF THE NATIONAL UNIVERSITY OF PEKING,

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SERIES B, VOLUME II,

FASCICLE III.

ON THE SEASONAL GROWTH IN PALAEOZOIC TETRACORALS AND THE CLIMATE DURING THE DEVONIAN PERIOD

BY

TING YING H. MA, D. Sc.

*Palæontologist to the National Geological Survey of China and
Professor of the National Central University, Nanking.*

WITH 22 PLATES AND 1 MAP

Published by the Geological Survey of China



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On the Seasonal Growth in Palaeozoic
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On the Seasonal Growth in Palaeozoic Tetracorals and the Climate During the Devonian Period

BY

TING YING H. MA

*Contribution from the Institute of Geology and Palæontology,
Tôhoku Imperial University, Sendai, Japan.*

I. INTRODUCTION

During the Year 1933, the present author has detected periodic change of growth of the irregularity of the size as well as arrangement of the elements in the vesicular tissue of some Palæozoic Tetracorals,¹⁾ and successively he also found that the same phenomenon occurs in Stromatoporoids from every Palæozoic and Mesozoic formation,²⁾ certain Palæozoic and Mesozoic Tabulate Corals, recent as well as fossil Hexacorals, and furthermore in an Ordovician Bryozoa which he occasionally examined.³⁾ In the works entitled "On the Seasonal Change of Growth in a Reef Coral, *Favia speciosa* (Dana), and the Water-Temperature of the Japanese Seas During the Latest Geological Times" and "On the Growth Rate of Reef Corals and the Water Temperature of the Japanese Islands During the Latest Geological Times" the same author has demonstrated not only that this feature in the recent as well as fossil forms indicates but nothing more than the annual cycle of growth in response to the seasonal change of the water temperature under which the animals had lived, but found also the fact that the temperature of the district, in which the polyps lived, is warmer and the length of the annual growth longer in the same species or in the same genus of the recent reef corals. From the length of annual growth in the same species of the recent as well as fossil reef corals obtained from various places and from different geological formations, the author has pointed out, furthermore, that the sea water temperature may have been much

1) T. Y. H. Ma: On the Seasonal Change of Growth in Some Palæozoic Corals, 1933.

2) See Bibliography 2, 5, 7, 22, 42, 62, 80, 83 and 85.

3) K. Ozaki: On Two Species of Ordovician Bryozoa from South Manchuria, 1930.

warmer during the time of the Raised Coral Reef (Lower Holocene) developed in the Japanese Islands than in the recent as well as the time during the Ryûkyû Limestone (Lowest Pleistocene in age according to S. Nomura and N. Zinbô)¹⁾ at the same district; and from the measurements of the annual growth in the reef corals he has concluded that the temperature of Tateyama district of the Main Islands of Japan at the time during the Raised Coral Reef may have been neither warmer nor much colder than that of the present sea of Amami-ôshima Islands of the Ryûkyû Group, and the temperature of the latter at that time may have been nearly similar to that of the present Ogasawara-zima i.e., 5°C or thereabout higher than that of the present-day at Tateyama and about 3°C for the monthly mean average of the coldest month at Amami-ôshima, and that the temperature of the Ryûkyû Limestone does not seem to have been much warmer than that of the present-day.

In the present work, the author has attempted to apply the same method to the Devonian Tetracorals, as far as possible, and from the measurements of annual length of growth in the same species or the same genus from various places, he also has tried to locate the equator during that time in Eurasian Continent.

In discussing seasonal change of growth in fossil corals there are two matters of prime importance; one is the exterior feature, the annulations or periodic swellings of growth, and the other is the interior peculiarities of the corals, R. Wedekind's theory of the septal cone of the Palæozoic Tetracorals.²⁾ The present author has examined samples of *Mesophyllum*, *Cystiphyllum*, *Keriophyllum*, *Ceratophyllum*, *Campophyllum* and *Ptenophyllum* as well as other forms from Eifel in Germany, Kwangsi in China and New York in North America together with the figures given by Edwards and Haime,³⁾ and Wedekind and Vollbrecht,⁴⁾ and in his opinion such phenomenon as the annulation in growth as well as the feature

1) S. Nomura and N. Zinbô: Marine Mollusca from the "Ryûkyû Limestone of Kikai-zima, Ryûkyû Group, p. 111, 1934.

2) R. Wedekind: Das Mitteldevon der Eifel, T. I, pp. 21-25, 1924.

3) Milne-Edwards and J. Haime: British Fossil Corals, pl. 31, fig. 2a; pl. 33, figs. 3b, 4, 1850-1854.

4) R. Wedekind: Das Mitteldevon der Eifel, T. II, pp. 25-41, figs. 32-64, 1935; R. Wedekind und E. Vollbrecht: Die Lytophyllidae des mittleren Mitteldevon der Eifel, pls. 1-38, 1931-1932.

upon which the theory of Professor R. Wedekind was based merely indicates the annual cycle of growth in response to the seasonal change of the water temperature.

II. THE CHARACTER OF SEASONAL CHANGE IN GROWTH

Horizontal elements. In the forms which exhibit the feature of seasonal change in growth, the vesicular tissue or the horizontal elements are arranged in different densities at different heights above the base of the corallite; namely, a part of the corallite in this type is provided with minute and densely crowded dissepiments or vesicles as well as tabulae, while the parts under and overlying it possess larger and less crowded dissepiments or vesicles and tabulae: and the elements in the densely crowded portion are, usually, thickened by the stereoplasmic deposits.

Vertical elements. The vertical elements or the septa as well as the other vertical tissue, in general, are more sensitive than the horizontal ones to the seasonal change of the water temperature, they are stronger in development in both the length and breadth at the densely crowded portion of the horizontal tissue.

III. MEASUREMENT OF ANNUAL LENGTH IN GROWTH

I. Genus **DISPHYLLUM** de Fromentel 1861.

1. **Disphyllum stachei** (Penecke)

1894 *Thamnophyllum Stachei* Penecke: Das Grazer Devon, p. 594, pl. VIII, figs. 1-3; pl. XI, figs. 1, 2.

1894 *Thamnophyllum Hornesi* Penecke: Ibid., p. 595, pl. VII, figs. 13, 14; pl. XI, fig. 3.

1894 *Thamnophyllum Murchisoni* Penecke: Ibid., p. 595, pl. VII, figs. 15-17.

Locality	Author	Pl.*	Fig.*	Annual Length
Plabutsch in Graz of Austria	Penecke	7	13, 14	4.50 mm.
"	"	7	17	3.50
Gaisberg in Graz of Austria	"	8	2	4.00

*Indicates the original plate and figure or figures of the author cited at the left.

2. *Disphyllum goldfussi* (Geinitz)

Pl. I, Figs. 1a-1d.

- 1826 *Cyathophyllum cæspitosum* Goldfuss: Petr. Germ., T. I, p. 60, pl. XIX, figs. 2a, 2b, 2c, 2d.
- 1826 *Cyathophyllum hexagonum* Goldfuss (pars): Ibid., p. 61, pl. XIX, figs. 5a, 5b, 5c, 5d.
- 1843 *Cyathophyllum cæspitosum* Römer: Verstein. d. Harzgebirges, p. 4, pl. II, fig. 10.
- 1853 *Cyathophyllum cæspitosum* Edwards and Haime: British Fossil Corals, p. 229, pl. 51, figs. 2, 2a, 2b.
- 1866 *Tæniocalamolopas adhæsa* Ludwig: Corallen aus paläolithischen Formationen, p. 218, pl. LXIII, figs. 4, 4a, 4b.
- 1866 *Astrocalamocyathus cæspitosus* Ludwig Ibid., p. 222, pl. LXII, figs. 2a-c.
- 1886 *Cyathophyllum cæspitosum* Frech: Cyath. u. Zaphr., p. 70, pl. III, figs. 9-14.
- 1892 *Campophyllum Gregorrii* Jack and Etheridge: Geology and Palæontology of Queensland and New Guinea, p. 60, pl. III, figs. 15-18.
- 1900 *Cyathophyllum cæspitosum* Lambe: A Revision of the Genera and Species of Canadian Palæozoic Corals, p. 145, pl. XII, figs. 3, 3a, 3b.
- 1900 *Cyathophyllum Araxis* Frech: Das Palæozoicum in Hocharmenien und Persien, p. 184, pl. XVII, figs. 5a, 5b, 5c, 5d, 5e.
- 1902 *Cyathophyllum cæspitosum* Lebedew: Bedeutung der Korallen in den devonischen Ablagerungen Russlands, p. 149, pl. II, figs. 18, 19, 20.
- 1903 *Cyathophyllum cæspitosum* Penecke: Das Sammelergebnis aus dem Oberdevon von Hadschin, p. 146, pl. IV, figs. 2a, 2b, 3a, 3b; pl. V, fig. 1.
- 1908 *Cyathophyllum cæspitosum* var. *breviscipiatum* Reed: Devonian Faunas of the Northern Shan States, p. 4, pl. I, figs. 3-6.
- 1920 *Cyathophyllum cæspitosum* var. *breviseptata* Yabe and Hayasaka: Palæont. of S. China, p. 136, pl. VIII, fig. 7.
- 1935 *Disphyllum goldfussi* Lang and Smith: On *Cyathophyllum cæspitosum* Goldfuss, p. 568, textfigs. 23, 24; pl. XXXV, figs. 4-8.

Locality	Author	Pl.	Fig.	Annual Length
Eifel or Bensberg, Germany	Goldfuss	19	2a	6.00
"	"	19	5b	7.00
	Lang &			

Locality	Author	Pl.	Fig.	Annual Length
Bensberg, Germany	Smith	35	4	7.00
Harz, Germany	Römer	2	10	6.50
"	Ludwig	63	4, 4a	5.00
Reinland, Germany	"	62	2	10.00 (?)
Refrath near Köln, Germany	Frech	3	9	5.00
"	"	3	13	5.00
Sadarak in Turan, Asia Minor	"	17	5e	4.00
Uchta in Timan, Northern Russia	Lebedew	2	19	No seasonal change
Hadschin in Asia Minor	Penecke	5	1	2.50
"	"	4	4a	2.50
Padaukpin, North Shan State	Reed	1	4-6	No seasonal change
Ping-wu-hsien, Szechuan, China	(6283)*	1	1b, 1c, 1d	"
Pas de Calais, France				10.00
	Edwards &			
Torquay, England	Haime	51	2	16.00

3. *Disphyllum caespitosum* (Goldfuss)

Pl. I, Fig. 2; Pl. II, Figs. 2a-2d.

- 1881 *Fascicularia caespitosa* Schlüter; Anthozoen des Devon, p. 103, pl. IX, figs. 6, 7.
- 1894 *Thamnophyllum trigeminum* Penecke: Das Grazer Devon, p. 596, pl. VIII, figs. 4-6.
- 1902 *Cyathophyllum carbonicum* Lebedew; Korallen in den devonischen Ablagerungen Russlands, p. 179, pl. IV, figs. 54-57.
- 1909 *Phacellophyllum caespitosum* Gürich: Leitfossilien, 2, Devon, p. 102, pl. XXXI, figs. 5a, 5b.
- 1935 *Disphyllum caespitosum* Land and Smith: On *Cyathophyllum caespitosum* Goldfuss, p. 573, textfigs. 28, 29; Pl. XXXV, figs. 1, 2.
- 1935 *Disphyllum trigemme* Lang and Smith: Ibid., p. 575, textfigs. 30, 31.

*Registered Number of the Institute of Geology and Palæontology, Tôhoku Imperial University, Sendai, Japan.

Locality	Author	Pl.	Fig.	Annual Length
Uchta in Timan, North Russia	Lebedew	4	56	12.00
Gerolstein in Eifel, Germany	(49104)	1	2	6.00
"	(68)			5.00

4. *Disphyllum minus* (Römer)

Pl. II, Figs. 1a-c.

- 1885 *Cyathophyllum minus* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 34, pl. I, figs. 3a, 4b.
- 1896 *Ceratophyllum augustius* Gürich: Das Paläozoicum im polnisch Mittelgebirge, p. 166, pl. IV, figs. 2a, 2b, 2c.
- 1902 *Cyathophyllum minus* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 149, pl. II, figs. 25-28; pl. III, figs. 32-35.
- 1903 *Cyathophyllum minus* Penecke: Das Sammelergebnis aus dem Oberdevon von Hadschin, p. 147, pl. IV, figs. 4a, 4b.
- 1914 *Cyathophyllum minus* Yakowlew: Die Korallen Rugosa, pl. I, figs. 1, 2.
- 1935 *Disphyllum minus* Lang and Smith: On *Cyathophyllum caespitosum* Goldfuss, p. 576, pl. XXXV, fig. 3.

Locality	Author	Pl.	Fig.	Annual Length
Grund in Harz, Germany	Frech	1	3a	6.00
"	(91)	2	1b, 1c	6.50
Poland	Gürich	4	2b	6.00
Uchta in Timan, Northern Russia	Lebedew	2	25	No seasonal change
"	"	2	26	"
"	"	2	28	"
"	"	3	34	"
"	"	3	35	"
Antitaurus in Anatolia, Asia Minor	Penecke	4	4b	2.50

5. *Disphyllum kunthi* (Dames)

Pl. I, Figs. 4a-c.

- 1868 *Lithostrotion cæspitosum* Dames; Ueber die in der Umgebung Freiburgs in Nieder-Schlesien auftretenden devonischen Ablagerungen, p. 492.
- 1869 *Cyathophyllum Kunthi* Dames: Zeitsch. deut. geol. Gesellsch., Bd. 21, p. 699.
- 1873 *Fascicularia Kunthi* Dybowski: Zoantharia rugosa, p. 406, pl. XIII, figs. 3, 4.
- 1885 *Cyathophyllum Kunthi* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 35, pl. I, figs. 4, 4a, 4b.
- 1920 *Cyathophyllum Kunthi* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 150, pl. III, figs. 36-38.

Locality	Author	Pl.	Fig.	Annual Length.
Schlesien, Germany	Frech	1	4b	4.50
„	(Krantz 10)	1	4a, 4c	4.50
Uchta in Timan, Northern Russia	Lebedew	3	38	No seasonal changes

6. *Disphyllum supradevonicum* (Penecke)

Pl. I, Figs. 3a-c.

- 1903 *Thamnophyllum supradevonicum* Penecke: Das Sammelergebnis aus dem Oberdevon von Hadschin, p. 144, pl. IV, figs. 1a, 1b.
- 1928 *Pexiphyllum rectum* Walther: Untersuchungen über die Mitteldevon-Oberdevongrenze, p. 130, figs. 20, 21.

Locality	Author	Pl.	Fig.	Annual Length
Hadschin in Anatolia, Asia Minor	Penecke	4	1b	4.50

II. Genus *MACGEEA* Webster 1889

7. *Macgeea solitaria* (Hall and Whitfield)

- 1886 *Cyathophyllum bathycalyx* Frech: Cyath. u. Zaphr., p. 67, pl. V, figs. 17-24; pl. VII, figs. 8-11.
- 1908 *Cyathophyllum bathycalyx* Reed: Devonian Faunas of the Northern Shan State, pp. 3-4, pl. I, fig. 2.
- 1924 *Macgeea solitaria* Fenton: Hackberry Stage of the Upper Devonian, p. 54, pl. IX, figs. 7-10.

- 1935 *Macgeea solitaria* Lang and Smith: On *Cyathophyllum cæspitosum* Goldfuss. p. 580, pl. XXXVII, figs. 1-3.

Locality	Author	Pl.	Fig.	Annual Length
Mühlberg near Gerolstein in Eifel, Germany	Frech	5	20	6.00
Padaukpin of Northern Shan States	Reed	1	2	9.00
North Central Iowa, U. S. A.	Fenton	9	7	6.00
"	"	9	8	6.00
"	Lang & Smith	37	3	5.50

8. *Macgeea multizonata* (Reed)

Pl. IV, Figs. 1a-b.

- 1922 *Cyathophyllum* (*Thamnophyllum*) *multizonatum* Reed: Devonian Fossils from Chitral and Pamirs, p. 12 pl. I, figs. 7-12; pl. II, figs. 1-7.
- 1935 *Macgeea multizonata* Lang and Smith: On *Cyathophyllum cæspitosum* Goldfuss, p. 580, pl. XXXVII, figs. 13-15.

Locality	Author	Pl.	Fig.	Annual Length
Chitral	Reed	1	7	13.00
"	"	1	9	11.00
"	"	2	2	11.00
"	"	2	3	13.00
"	"	2	5	9.00
Gerolstein in Eifel, Germany		4	1a	5.50

III. Genus **PRISMATOPHYLLUM** Simpson 1900

9. *Prismatophyllum quadrigeminum* (Goldfuss)

Pl. II, Figs. 3a-b; Pl. III, Figs. 1a-b.

- 1826 *Cyathophyllum quadrigeminum* Goldfuss (pars): Petr. Germ., T. 1, p. 59, pl. XIX, fig. 1b.
- 1935 *Prismatophyllum quadrigeminum* Lang and Smith: On the Genotype of *Columnaria* Goldfuss, p. 430, pl. XII, figs. 5-7; textfig. 3.

Locality	Author	Pl.	Fig.	Annual Length
Bensberg, Germany	Lang & Smith	12	6	10.00
Refrath near Köln, Germany	(80)	2	3a	7.50
Perques, Pas de Calais, France	(13)	3	1a	8.00

10. *Prismatophyllum darwini* (Frech)

- 1881 *Columniphyllum sulcatum* Quenstedt: Röhren- und Sternkorallen, p. 523, pl. 162, fig. 23.
 1881 *Campophyllum quadrigeminum* Schlüter: Anthozoen des Devon, p. 98, pl. XII, fig. 4.
 1885 *Cyathophyllum Darwini* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 36.
 1886 *Cyathophyllum Darwini* Frech: Cyath. u. Zaphr., p. 73, pl. III, figs. 2, 2a.
 1903 *Cyathophyllum Darwini* Penecke: Das Sammelergebnis aus dem Oberdevon Hadschin, p. 147, pl. V, figs. 2a, 2b.

Locality	Author	Pl.	Fig.	Annual Length
Sötenich, Germany	Frech	3	2	No seasonal change
Hadschin, Antitaurus, Asia Minor	Penecke	5	2b	5.50

11. *Prismatophyllum sedgwicki* (Edwards and Haime)

Pl. III, Figs. 3a-b.

- 1853 *Cyathophyllum Sedgwicki* Edwards and Haime: British Fossil Corals, p. 231, pl. 32, figs. 3, 3a.
 1853 *Acervularia Battersbyi* Idem.: Ibid., p. 239, pl. 54, figs. 2, 2a.
 1853 *Acervularia Davidsoni*? Hall: Geol. Iowa, vol. I, p. 476, pl. I, figs. 8a, 8b.
 1858 *Acervularia profunda* Hall: Ibid., p. 477, pl. I, figs. 7a, 7b, 7c.
 1876 *Cyathophyllum Sedgwicki* Rominger: Fossil Corals, p. 107, pl. 37, fig. 4.
 1885 *Cyathophyllum Sedgwicki* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 42, pl. IV, fig. 6.
 1885 *Phillipsastrea ananas* Frech (pars): Ibid., p. 49, pl. II, figs. 1, 2, 5, 5a, 5b; pl. III, fig. 9.
 1900 *Prismatophyllum Davidsoni* Simpson: New Genera of Palæozoic Rugose Corals, p. 218 fig. 42.

- 1902 *Cyathophyllum Sedgwicki* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 152, pl. III, figs. 39, 40, 41.
- 1903 *Cyathophyllum Sedgwicki* Penecke: Das Sammelerggebnis aus dem Oberdevon von Hadschin, p. 147, pl. V, figs. 3a, 3b, 3c.
- 1924 *Acervularia bassleri* Fenton: Hackberry Stage of Upper Devonian, p. 58, pl. XIII, fig. 2, pl. 14, figs. 4, 5.
- 1924 *Acervularia bassleri depressa* Fenton: Ibid., p. 60, pl. XII, figs. 1, 2.
- 1924 *Acervularia bassleri magna* Fenton: Ibid., p. 61, pl. XIV, fig. 6.

Locality	Author	Pl.	Fig.	Annual Length
Uchta in Timan, Northern Russia	Lebedew	3	40	No seasonal change
Hadschin in Antitaurus, Asia Minor	Penecke	5	3b	3.50
North Central Iowa, U. S. A.	Fenton	14	5	5.00
Johnson county, Iowa State, U. S. A.	(12)	3	3a	6.00

12. *Prismatophyllum goldfussi* (Edwards and Haime)

Pl. III, Figs. 2a-b.

- 1826 *Cyathophyllum Ananas* Goldfuss: Petr. Germ., T. 1, p. 60, pl. XIX, figs. 4a, 4b.
- 1855 *Acervularia Goldfussi* Edwards and Haime: British Fossil Corals, p. 236, pl. 53, figs. 3, 3a.
- 1853 *Acervularia coronata* Idem.: Ibid., p. 237, pl. 53, figs. 4, 4a, 4b.
- 1853 *Acervularia limitata* Idem.: Ibid., p. 238, pl. 54, figs. 1, 1a.
- 1853 *Acervularia Römeri* Idem.: Ibid., p. 239, pl. 54, figs. 3, 3a.
- 1881 *Heliophyllum troscheli* Schlüter: Anthezoen des Devon, p. 85, pl. VIII, figs. 3, 4.
- 1881 *Heliophyllum cf. limitatum* Schlüter: Ibid., p. 87, pl. VIII, figs. 1, 2.
- 1885 *Phillipsastrea ananas* Frech (pars): Die Korallenfauna des Oberdevons in Deutschland, p. 49, pl. II, figs. 3a, 3b, 4, 4a, 4b; pl. III, figs. 1, 1a, 2, 5, 14.
- 1885 *Phillipsastrea pentagona* Frech (pars): Ibid., p. 54, pl. III, figs. 6, 9.
- 1885 *Phillipsastrea Römeri* Frech: Ibid., p. 57, pl. IV, figs. 1-5.
- 1902 *Acervularia limitata* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 153, pl. V, figs. 70, 71, 72.
- 1903 *Phillipsastræa Schafferi* Penecke: Das Sammelerggebnis aus dem Oberdevon von Hadschin, p. 147, pl. VI, figs. 1a, 1b, 2a, 2b; pl. VII, fig. 1.
- 1924 *Acervularia inequalis* Fenton: Hackberry Stage of the Upper Devonian, p. 56, pl. XIV, figs. 7, 8.
- 1927 *Acervularia whitfieldi* Fenton: Ibid., p. 57, pl. XIV, figs. 1, 2, 3.

Locality	Author	Pl.	Fig.	Annual Length
Uchta in Timan, Northern Russia	Lebedew	5	71	No seasonal change
Aachen, Germany	Schlüter	8	4	4.50
Violenberg in Grund, Harz, Germany	Frech	3	14	4.70
Hadschin in Antitaurus, Asia Minor	Penecke	6	1b	3.50
"	"	6	2b	4.00
North Central Iowa U. S. A.	Fenton	14	8	6.50
Warsaw in Illinois, U. S. A.	(36501)	3	2a	5.00

13. *Prismatophyllum pentagonum* (Goldfuss)

- 1826 *Cyathophyllum pentagonum* Goldfuss: Petr. Germ., T. 1, p. 60, pl. XIX, fig. 3.
- 1853 *Acervularia pentagona* Edwards and Haime: British Fossil Corals, p. 238, pl. 53, figs. 5, 5a, 5b.
- 1885 *Phillipsastrea pentagona* Frech (pars): Die Korallenfauna des Oberdevons in Deutschland, p. 54, pl. III, figs. 7, 7a, 8, 10; pl. VIII, fig. 3.
- 1903 *Phillipsastræa microastræa* Penecke: Das Sammelergebnis aus dem Oberdevon von Hadschin, p. 149, pl. VI, figs. 3a, 3b; pl. VII, fig. 2.

Locality	Author	Pl.	Fig.	Annual Length
Stollberg in Harz, Germany	Frech	3	7a	5.50
Hadschin in Antitaurus, Asia Minor	Penecke	6	3b	4.50

14. *Prismatophyllum pentagonum* var. *micrommata* (Römer)

- 1885 *Phillipsastrea pentagona* var. *micrommata* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 56, pl. III, figs. 11, 12, 13, 13a; pl. VIII, fig. 1.

Locality	Author	Pl.	Fig.	Annual Length
Rubeland, Germany	Frech	3	13a	2.40

15. *Prismatophyllum? douvillei* (Frech)

- 1853 *Spongophyllum Sedgwicki* Edwards and Haime (pars): British Fossil Corals, p. 242, pl. 56, figs. 2, 2b, 2c.
 1911 *Cyathophyllum Douvillei* Frech in Richthofen's China, vol. V, p. 42, pl. X, figs. 1a, 1b, 2.
 1912 *Cyathophyllum Douvillei* Mansuy: Géol. du Yun-nan Oriental, Pt. II, Paleont., p. 71, pl. XIII, figs. 3a, 3b.

Locality	Author	Pl.	Fig.	Annual Length
Ta-i-ti, Yunnan, China	Frech	10	1b	No seasonal change

16. *Prismatophyllum? douvillei* var. *sinensis* (Yabe and Hayasaka)

Pl. IV, Figs. 2a-b.

- 1920 *Cyathophyllum Douvillei* var. *sinensis* Yabe and Hayasaka: Palæont. of S. China, p. 135, pl. IX, figs. 11a, 11b.

Locality	Pl.	Fig.	Annual Length
Yang-liu-shu, Ta-kuan-ting, Yunnan, China	4	2b	No seasonal change

14. Genus *PACHYPHYLLUM* Edwards and Haime 185017. *Pachyphyllum devoniense* Edwards and Haime

- 1853 *Pachyphyllum Devoniense* Edwards and Haime: British Fossil Corals, p. 234, pl. 52, figs. 5, 5a.
 1883 *Pachyphyllum Devoniense* Römer: Leth. palæoz., p. 393, textfig. 93.
 1885 *Phillipsastrea (Pachyphyllum) Devoniensis* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 67, pl. VI, figs. 2, 2a.
 1924 *Pachyphyllum regulare* Fenton: Hackberry Stage of the Upper Devonian, p. 49, pl. X, figs. 1, 2; pl. XI, figs. 1, 2.

Locality	Author	Pl.	Fig.	Annual Length
Grund in Harz, Germany	Frech	6	2a	5.00
North Central Iowa, U. S. A.	Fenton	11	1	7.00

18. **Pachyphyllum ibergense** (Römer)

1885 *Phillipsastrea* (*Pachyphyllum*) *Ibergensis* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 66, pl. VI, figs. 1, 1a, 1b.

Locality	Author	Pl.	Fig.	Annual Length
Grund in Harz, Germany	Frch	6	1b	6.00

19. **Pachyphyllum woodmani** (White)

1924 *Pachyphyllum woodmani* Fenton: Hackberry Stage of the Upper Devonian, p. 46, pl. VII, figs. 1-3; pl. VIII, fig. 2; pl. IX, figs. 11, 12; pl. X, fig. 3.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	7	1	4.00
„	Fenton	7	3	7.00
„	(186)			6.00

20. **Pachyphyllum crassicostatum** Webster

1924 *Pachyphyllum crassicostatum* Fenton: Hackberry Stage of the Upper Devonian, p. 51, pl. VIII, fig. 1; pl. IX, figs. 1-5.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	9	5	6.50

21. **Pachyphyllum crassicostatum** var. *nanum* Fenton

1924 *Pachyphyllum crassicostatum* var. *nanum* Fenton Hackberry Stage of the Upper Devonian, p. 52, pl. IX, fig. 6.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	9	6	4.00

V. Genus **CAMPOPHYLLUM** Edwards and Haime 185022. **Campophyllum lindströmi** (Frech)

Pl. XI, Figs. 1a-1b; Pl. XXI, Figs. 2-3; XXII, Figs. 1a-4d.

- 1826 *Cyathophyllum dianthus* Goldfuss (pars) Petr. Germ., T. 1, p. 54, pl. XVI, figs. 1c, 1d.
 1886 *Cyathophyllum dianthus* Frech: Cyath. u. Zaphr., p. 68, pl. I, figs. 1-6.
 1886 *Cyathophyllum Lindströmi* Frech (pars) Ibid., p. 69, pl. I, figs. 9, 10, 11, 12, 14, 15, 16, 17.
 1886 *Cyathophyllum* cf. *Lindströmi* Frech: Ibid., p. 69, pl. I, figs. 13, 13a.
 1889 *Campophyllum Sötenicum* Schlüter: Anthozoen des rheinischen Mittel-Devon, p. 39, pl. III, figs. 1-6.

Locality	Author	Pl.	Fig.	Annual Length
Eifel, Germany	Goldfuss	16	1c	10.00
"	"	16	1d	6.50
Gerolstein in Eifel, Germany	(88)	11	1b	13.00
Iserlohn, Germany	Frech	1	6	10.00
"	"	1	1	10.00
Sötenich, Germany	"	1	16	12.00
Eifel, Germany	Schlüter	3	2	10.00
Hsiang-hsiang-hsien, Hunan, China	D 16, 2412 ¹⁾	21	2	14.00
"	D 16, 2190	21	3	20.00
"	D 16, 2367	22	1a	15.00
"	D 16, 2426	22	2c	12.50
"	D 16, J	22	3a	13.00
"	D 16, 2204	22	4a	13.00
"	D 16, 2384			13.50
"	D 16, 2349			13.00
"	D 16, 2284			14.00
"	D 16, 2232			25.00

23. **Campophyllum lindströmi** var. **ehlersi** (Fenton)

- 1924 *Tabulophyllum ehlersi* Fenton: Hackberry Stage of the Upper Devonian, p. 34, pl. III, fig. 4; pl. VI, figs. 13-16.

1) Register Number of the Geological Survey of China.

Locality	Author	Pl.	Fig.	Annual Length
Rockford in Iowa State, U. S. A.	Fenton	6	14	12.00

24. **Campophyllum annulatum** (Peetz)

Pl. VI, Figs. 3a-c.

- 1901 *Cyathophyllum annulatum* Peetz: Beitr. z. Kenntnis der Fauna aus den devonischen Schichten am Rande des Steinkohlenbassins von Kusnetz, p. 380, pl. I, figs. 13, 13b, 13c.

Locality	Author	Pl.	Fig.	Annual Length
Ur River, Kusnetz, Siberia	Peetz	1	13a	5.00

25. **Campophyllum dianthus** (Goldfuss)

Pl. V, Figs. 1a-2b.

- 1826 *Cyathophyllum dianthus* Goldfuss (pars): Petr. Germ., T. 1, p. 54, pl. XV, fig. 13.
 1881 *Cyathophyllum dianthus* Quenstedt: Röhren- und Sternkorallen, p. 551, pl. 163, fig. 17.

Locality	Author	Pl.	Fig.	Annual Length
Eifel, Germany	Goldfuss	15	13	5.50
Gerolstein in Eifel, Germany	(82)			9.00
"	(82)			10.00
"	(83)	5	1b	13.00
"	(84)	5	2b	9.50

VI. Genus **ENDOPHYLLUM** Edwards and Haime 185026. **Endophyllum bowerbanki** Edwards and Haime

- 1853 *Endophyllum bowerbanki* Edwards and Haime: British Fossil Corals, p. 233, pl. 53, fig. 1.
 1889 *Endophyllum bowerbanki* Schlüter: Anthozoen des rheinischen Mittel-Devon, pp. 52-54, pl. VI, figs. 1-3.
 1929 *Endophyllum bowerbanki* Jones: *Endophyllum* and *Spongophyllum*, p. 85, pl. X, figs. 1, 2.

Locality	Author	Pl.	Fig.	Annual Length
Holthausen in Westfalen, Germany	Schlüter	6	1	4.50
"	"	6	3	5.00
Torquay in England	Jones	10	2	5.00

27. *Endophyllum abditum* (Edwards and Haime)

1853 *Endophyllum abditum* Edwards and Haime: British Fossil Corals, p. 233, pl. 52, fig. 2.

1929 *Endophyllum abditum* Jones: *Endophyllum* and *Spongophyllum*, p. 87, pl. X, figs. 3, 4.

Locality	Author	Pl.	Fig.	Annual Length
South Devon in England	Jones	10	4	6.00

28. *Endophyllum weberi* (Lebedew)

1902 *Cyathophyllum* (*Donacophyllum*) *Weberi* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 178, pl. IV, figs. 49-53.

Locality	Author	Pl.	Fig.	Annual Length
Uchta in Timan, Northern Russia	Lebedew	4	49	19.00
"	"	4	50	20.00

29. *Endophyllum keyserlingi* (Lebedew)

1902 *Campophyllum Keyserlingi* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 152, pl. V, figs. 67, 68, 69.

Locality	Author	Pl.	Fig.	Annual Length
Uchta in Timan, Northern Russia	Lebedew	5	67	15.00

VII. Genus *TABULOPHYLLUM* Fenton 1924

30. *Tabulophyllum rectum* Fenton

1924 *Tabulophyllum rectum* Fenton: Hackberry Stage of the Upper Devonian, p. 31, pl. VI, figs. 8-12.

1924 *Tabulophyllum regulare* Fenton: Ibid., p. 33, pl. VI, figs. 1, 1a.

1924 *Tabulophyllum erraticum* Fenton: Ibid., p. 36, pl. VI, figs. 3-7.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	6	1	7.50
"	"	6	6	7.00
"	"	6	7	6.50
"	"	6	8	7.00
"	"	6	10	6.50
"	"	6	11	7.50

31. *Tabulophyllum rotundum* Fenton

1924 *Tabulophyllum rotundum* Fenton: Hackberry Stage of the Upper Devonian, p. 35, pl. II, figs. 5-10.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	2	5	13.00
"	"	2	10	13.00

32. *Tabulophyllum magnum* Fenton

1924 *Tabulophyllum magnum* Fenton: Hackberry Stage of the Upper Devonian, p. 38, pl. IV, figs. 1, 2, 3.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	4	1	18.00
"	"	4	2	18.00

33. *Tabulophyllum ponderosum* Fenton

1924 *Tabulophyllum ponderosum* Fenton: Hackberry Stage of the Upper Devonian, p. 40, pl. IV, figs. 4, 5; pl. V, figs. 5, 6.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	4	4	25.00
"	"	4	5	25.00

34. *Tabulophyllum robustum* Fenton

1924 *Tabulophyllum robustum* Fenton: Hackberry Stage of the Upper Devonian, p. 37, pl. V, figs. 1-3.

Locality	Author	Pl.	Fig.	Annual Length
North Central Iowa, U. S. A.	Fenton	5	1	7.00
"	"	5	2	10.00

35. *Tabulophyllum ellipticum* (Hall and Whitfield)

1891 *Campophyllum ellipticum* Whiteaves: The Fossils of the Devonian Rocks of the Mackenzie River Basin, p. 202, pl. 27, figs. 5, 6.

1923 *Chonophyllum ellipticum* Branson: The Devonian of Missouri, p. 51, text-fig. 3; pl. I, figs. 2-5; pl. II, fig. 6.

Locality	Author	Pl.	Fig.	Annual Length
Snyder Creek in Missouri, U. S. A.	Branson	1	2	30.00
"		1	3	24.00
"	"	1	4	22.00
"	"	1	5	20.00
Hay River in Mackenzie River Basin of Canada	Whiteaves	27	5	7.00

36. *Tabulophyllum callawayense* (Branson)

1923 *Diplophyllum callawayensis* Branson: The Devonian of Missouri, p. 50, pl. III, fig. 4.

Locality	Author	Pl.	Fig.	Annual Length
Boone in Missouri, U. S. A.	Branson	3	4	16.00

37. **Tabulophyllum priscum** (Frech)

1885 *Endophyllum priscum* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 76, pl. VII, fig. 2; pl. X, figs. 2, 2a, 2b, 2c.

Locality	Author	Pl.	Fig.	Annual Length
Aachen, Germany	Frech	10	2b	7.00

38. **Tabulophyllum tenuissimum** (Walther)

1928 *Aplythophyllum tenuissimum* Walther: Untersuchungen über die Mitteldevon-Oberdevongrenze, pp. 143-144, figs. 31, 32.

Locality	Author	Fig.	Annual Length
Walbheim in Rheinland, Germany	Walther	31	11.00

39. **Tabulophyllum bartini** (Charles)

1933 *Glossophyllum Bartini* Charles: Contribution à l'Etude des Terrains paléozoïques de l'Anatolie du Nord-Ouest (Asie Mineure), p. 119, pls. IV, et V, figs. 10-19.

Locality	Author	Pl.	Fig.	Annual Length
Anatolia in Asia Minor	Charles	5	17	10.00
"	"	5	19	7.00

40. **Tabulophyllum nicolai-michælidis** (Frech)

1900 *Endophyllum Nicolai-Michælidis* Frech: Das Paläozoicum in Hocharmenien und Persien, p. 185, pl. XVII, figs. 1a-d.

Locality	Author	Pl.	Fig.	Annual Length
Sadarak, Turan, Asia Minor	Frech	17	1d	5.00

41. **Tabulophyllum yunnanenes** (Reed)

- 1927 *Campophyllum yunnanense* Reed: Palæozoic and Mesozoic Fossils from Yunnan, p. 10, pl. I, figs. 6-11.

Locality	Author	Pl.	Fig.	Annual Length
Man-kuan, Chin-chang-kai, Yunnan China	Reed	1	7	No seasonal change

42. *Tabulophyllum birmanicum* (Reed)

- 1908 *Cuathophyllum birmanicum* Reed: Devonian Faunas of the Northern Shan States, pp. 6-7, pl. I, figs. 11, 11a; pl. II, figs. 1, 1a.

Locality	Author	Pl.	Fig.	Annual Length
Padaukpin, Shan States	Reed	1	11	14.00
"	"	2	1a	16.00

VIII. Genus *CERATOPHYLLUM* Gürich 1896

43. *Ceratophyllum ceratites* (Goldfuss)

Pl. IV, Figs. 4, 5a-b, 6a-c.

- 1826 *Cyathophyllum ceratites* Goldfuss: Petr. Germ., T. 1, p. 57, pl. XVII, figs. 2, 2a-2h.
 1910 *Cyathophyllum ceratites* Yakowlew: Korallen rugosa, p. 7, textfigs. 6-8; pl. I, figs. 1, 2.
 1911 *Cyathophyllum ceratites* Frech in Richthofen's China, Vol. V, p. 41, pl. VI, figs. 1a-1c.

Locality	Author	Pl.	Fig.	Annual Length
Uchta in Timan, Northern Russia	Yakowlew:	Textfig.	7	12.00
"	"	"	8	10.00
"	"	1	1	12.00
Lou-nan, S. Yunnan, China	Frech	6	1a	14.00
Eifel or Bensberg, Germany	Goldfuss	17	2d	3.50
"	"	17	2e	4.00
"	"	17	2f	4.00
"	"	17	2h	4.50
Gerolstein in Eifel, Germany	(62)	4	4	4.00
"	(62)	4	5a, 5b	4.00
La Baconniere in France	(49144)			5.50

IX. Genus **GRYPOPHYLLUM** Wedekind 192144. **Grypophyllum gracile** Wedekind

- 1902 *Cyathophyllum* aff. *isactis* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 105, pl. III, figs. 42-45.
- 1925 *Grypophyllum gracile* Wedekind: Das Mitteldevon der Eifel, T. II, p. 22, pl. 5, figs. 28, 29.
- 1925 *Grypophyllum regressum* Wedekind: Ibid., p. 22, pl. 5, figs. 30, 31.

Locality	Author	Pl.	Fig.	Annual Length
Petschera Pishma River in Timan, Northern Russia	Lebedew	3	42	10.00
Hand in Berg.-Gladbach, Eifel, Germany	Wedekind	5	28	4.00
„	„	5	31	4.00

45. **Grypophyllum normale** Wedekind

- 1925 *Grypophyllum normale* Wedekind: Das Mitteldevon der Eifel, T. II, p. 22, pl. 5, figs. 25, 26.

Locality	Author	Pl.	Fig.	Annual Length
Hand in Berg.-Gladbach, Eifel, Germany	Wedekind	5	26	5.40

46. **Grypophyllum timanicum** (Lebedew)

Pl. XI, Figs. 4a-c.

- 1902 *Cyathophyllum timanicum* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 179, pl. V, figs. 64-66.

Locality	Author	Pl.	Fig.	Annual Length
Petschera in Timan, Northern Russia	Lebedew	5	64	15.00

47. **Grypophyllum** sp.

- 1902 *Cyathophyllum timanicum* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 151, pl. V, figs. 58-60.

Locality	Author	Pl.	Fig.	Annual Length
Petschera Pishma River in Timan, Northern Russia	Lebedew	5	60	20.00

48. **Grypophyllum?** sp.

1892 *Cyathophyllum* sp. ind. Jack and Etheridge: Geology and Palæontology of Queensland and New Guinea, p. 59, pl. III, figs. 11, 12.

Locality	Author	Pl.	Fig.	Annual Length
Queensland	Jack & Etheridge	3	11	5.50

X. Genus **SPONGOPHYLLUM** Edwards and Haime 1850

49. **Spongophyllum stuckenbergi** (Lebedew)

Pl. XVII, Figs. 3a-b.

1902 *Cyathophyllum Stuckenbergi* Lebedew: Korallen in den devonischen Ablagerungen Russlands, p. 179, pl. II, figs. 21-24.

The feature of the seasonal change of growth is quite wanting in the form which has been described and figured by Lebedew from Uchta in Timan, Northern Russia.

50. **Spongophyllum elongatum** Schlüter

Pl. VI, Figs. 2a-b.

1881 *Spongophyllum elongatum* Schlüter: Anthozoen des Devon, p. 94, pl. XI, figs. 1-5.

1885 *Endophyllum elongatum* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 928, pl. XLI, fig. 4.

Locality	Reg. No.	Pl.	Fig.	Annual Length
Pelm in Eifel, Germany	(36500)	6	2a	7.50

51. **Spongophyllum kunthi** Schlüter

Pl. VI, Figs. 1a-b.

- 1881 *Spongophyllum Kunthi* Schlüter: Anthozoen des Devon, p. 96, pl. XI, figs. 4, 5; pl. XII, figs. 1, 2.

Locality	Author	Pl.	Fig.	Annual Length
Eifel, Germany	Schlüter	12	1	6.00
Gerolstein in Eifel, Germany	(36499)	6	1a	6.00

52. **Spongophyllum semiseptatum** Schlüter

Pl. IV, Figs. 3a-c.

- 1881 *Spongophyllum semiseptatum* Schlüter: Anthozoen des Devon, p. 95, pl. IX, figs. 1-3.
 1925 *Spongophyllum semiseptatum* Wedekind: Das Mitteldevon der Eifel, T. II, p. 50, pl. 4, figs. 21-24.

Locality	Reg. No.	Pl.	Fig.	Annual Length
Sötenich in Eifel, Germany	(49131)	4	3a	10.00

XI. Genus **PTENOPHYLLUM** Wedekind 192453. **Ptenophyllum vermiculare** (Goldfuss)

Pl. VII, Figs. 1a-2b.

- 1826 *Cyathophyllum vermiculare* Goldfuss: Petr. Germ., T. 1, p. 58, pl. XVII, figs. 1-3.
 1866 *Astrocyathus vermicularis* Ludwig: Corallen aus paläolithischen Formationen, p. 208, pl. LV, figs. 2, 2a.
 1886 *Cyathophyllum vermiculare* Frech: Cyath. u. Zaphr., p. 62, pl. II, figs. 1, 2, 3, 3a, 5.

Locality	Author	Pl.	Fig.	Annual Length
Eifel, Germany	Goldfuss	17	4	9.00
Bensberg, Germany	Ludwig	55	2	12.00
Hand in Paffrath, Germany	Frech	2	3	9.00
Büchel in Berg.-Gladbach, Germany	„	2	5	12.00
Gerolstein in Eifel, Germany	(49117)	7	2a	8.00

54. **Ptenophyllum vermiculare** mut. **præcursor** (Frech)

- 1886 *Cyathophyllum vermiculare* mut. *præcursor* Frech: Cyath. u. Zaphr., p. 63, pl. II, figs. 4, 6, 7, 8, 9, 10.
- 1900 *Cyathophyllum vermiculare* mut. *præcursor* Frech: Das Paläozoicum in Hocharmenien und Persien, p. 184, pl. XVII, figs. 2a, 2b.

Locality	Author	Pl.	Fig.	Annual Length
Eifel, Germany	Frech	2	4	9.00
Gerolstein in Eifel, Germany	„	2	8	9.00
Sadarak in Turan, Asia Minor	„	17	2a	5.00

55. **Ptenophyllum heterophyllum** (Edwards and Haime)

- Pl. VII, Fig. 3; Pl. VIII, Figs. 1a-2b; Pl. IX, Figs. 1a-2d; Pl. X, Figs. 1a-2f; Pl. XI, Figs. 2a-e.
- 1853 *Cyathophyllum obtortum* Edwards and Haime: British Fossil Corals, p. 225, pl. 49, fig. 7.
- 1853 *Hallia Pengellyi* Edwards and Haime (pars): Ibid., p. 223, pl. 49, fig. 6.
- 1886 *Cyathophyllum heterophyllum* Frech: Cyath. u. Zaphr., p. 59, pl. VI, figs. 5-10.
- 1923 *Ptenophyllum præmaturum* Wedekind: Die Gliederung des Mitteldevons auf Grund von Korallen, p. 27, fig. 2.
- 1923 *Ptenophyllum n. sp.* Wedekind: Ibid., p. 30, fig. 5.
- 1923 *Ptenophyllum intortum* Wedekind: Ibid., p. 30, fig. 6.
- 1924 *Ptenophyllum* Wedekind: Das Mitteldevon der Eifel, T. I, p. 37, fig. 49.
- 1924 *Ptenophyllum simplex* Wedekind: Ibid., p. 38, figs. 50-53.
- 1924 *Ptenophyllum nohnense* Wedekind: Ibid., p. 40, figs. 54-57.
- 1924 *Ptenophyllum radiatum* Wedekind: Ibid., p. 41, fig. 58.
- 1924 *Ptenophyllum princeps* Wedekind: Ibid., p. 43, fig. 59.
- 1924 *Ptenophyllum filosa* Wedekind: Ibid., p. 43, figs. 60, 61.
- 1924 *Ptenophyllum involutum* Wedekind: Ibid., p. 44, fig. 62.
- 1924 *Astrophyllum gerolsteinense* Wedekind: Ibid., p. 45, figs. 63-75.
- 1924 *Rhopalophyllum fibratum* Wedekind: Ibid., pp. 51, 62, figs. 76-82, 97.
- 1924 *Rhopalophyllum intratum* Wedekind: Ibid., p. 54, figs. 83, 84, 85.
- 1924 *Rhopalophyllum lacinatum* Wedekind: Ibid., p. 55, fig. 86.
- 1924 *Rhopalophyllum cicatricosum* Wedekind: Ibid., p. 56, fig. 87.
- 1924 *Rhopalophyllum pseudofibratum* Wedekind: Ibid., p. 57, figs. 88, 89; p. 62, fig. 98.
- 1924 *Rhopalophyllum spinosum* Wedekind: Ibid. p. 58, figs. 90-93.

1924 *Rhopalophyllum scissum* Wedekind: Ibid., p. 59, figs. 94, 95.

1924 *Rhopalophyllum heterophyllum* Wedekind: Ibid., p. 62, fig. 97.

1924 *Rhopalophyllum intortum* Wedekind: Ibid., p. 64, fig. 99.

Locality	Author	Pl.	Fig.	Annual Length
Auburg of Gerolstein in Eifel, Germany	Frech	6	10	5.00
Gerolstein in Eifel, Germany	Wedekind		73	4.50
Uxheim of Hillesheim, Eifel, Germany	"		93	5.00
Gerolstein in Eifel, Germany	(79)	8	2a, 2b	7.00
"	(75)	9	1b, 1c	8.00
Auburg Gerolstein in Eifel, Germany	(49090)	8	1i	6.50
Gerolstein in Eifel, Germany		14	2	4.50
"	(49111)	10	2f	6.50
Auburg of Gerolstein in Eifel, Germany	(77)	9	2d	4.50
"	(49089)	10	1a, 1b	6.00

VII. Genus **KERIOPHYLLUM** Wedekind 1924

56. **Keriophyllum heterophylloides** (Frech)

Pl. XII, Figs. 1a-d.

1885 *Cyathophyllum heterophylloides* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 30, pl. I, figs. 2, 2a-2c.

1920 *Cyathophyllum heterophylloides* Yabe and Hayasaka: Palæont. of S. China, p. 134, pl. VIII, fig. 5; pl. XI, figs. 5a, 5b, 5c.

Locality	Author	Pl.	Fig.	Annual Length
Grund in Harz, Germany	Frech	1	2b	5.00
Hsing-an-hsien, Kwangsi, S. China	(6284)	12	1c, 1d	10.00

57. **Keriophyllum proliferum** (Frech)

Pl. XII, Figs. 3a-b.

1885 *Hallia prolifera* Frech: Die Korallenfauna des Oberdevons in Deutschland, p. 82, pl. VII, figs. 5, 5a, 5b.

Locality	Author	Pl.	Fig.	Annual Length
Kleiner Winterberg in Grund, Harz, Germany	Frech	7	5b	2.00
Buffalo in New York, U. S. A.	(92)	12	3a	5.00

58. **Keriophyllum** sp.

Pl. XII, Figs. 2a-b.

Locality	Reg. No.	Pl.	Fig.	Annual Length
Auburg of Gerolstein in Eifel, Germany	(49108)	12	2a	3.00

XIII. Genus **DOHMOPHYLLUM** Wedekind 192459. **Dohmophyllum tinocystis** (Frech)

- 1843 *Strombodes plicatum* Römer (pars): Verstein. d. Harzge., p. 4, pl. 11, figs. 7, 8.
 1885 *Cyathophyllum tinocystis* Frech: Dis Korallenfauna des Oberdevons in Deutschland, p. 28, pl. I, figs. 1, 1a.

Locality	Author	Pl.	Fig.	Annual Length
Grund in Harz, Germany	Römer	2	8	7.00
„	Frech	1	1a	8.00

60. **Dohmophyllum tinocystis** var. **carnica** (Vinassa)

- 1918 *Cyathophyllum tinocystis* Frech var. *carnica* Vinassa de Regny: Coralli mesodevonicici della Carnia, p. 70, pl. I, fig. 1.

Locality	Author	Pl.	Fig.	Annual Length
Collina, Italy	Vinassa	1	1	3.50

61. **Dohmophyllum helianthoides** (Goldfuss)

Pl. XIII, Fig. 1.

- 1826 *Cyathophyllum helianthoides* Goldfuss (pars): Petr. Germ., T. 1, pp. 60, 61, pl. XX, figs. 2a, 2b, 2c, 2d, 2e, 2h.
- 1912 *Cyathophyllum heliantoides* Mansuy: Etude Géol. du Yun-nan Oriental, p. 48, pl. VII, fig. 9.

Locality	Author	Pl.	Fig.	Annual Length
Po-si in Yunnan, Southern China	Mansuy	7	9	10.00
Gerolstein in Eifel, Germany	(71)	13	1	5.50

62. **Dohmophyllum helianthoides** var. **spinulosum** (Reed)

- 1908 *Cyathophyllum helianthoides* var. *spinulosum* Reed: Devonian Faunas of Northern Shan States, pp. 4-5, pl. I, figs. 7, 8, 8a.

Locality	Author	Pl.	Fig.	Annual Length
Padaukpin, Shan States	Reed	1	8	20.00

63. **Dohmophyllum involutum** Wedekind

Pl. XIII, Figs. 2a-c.

- 1923 *Dohmophyllum involutum* Wedekind: Die Gliederung des Mitteldevons auf Grund von Korallen, p. 30, fig. 7.
- 1924 *Dohmophyllum involutum* Wedekind: Das Mitteldevon der Eifel, T. 1, p. 75, fig. 108.
- 1924 *Dohmophyllum Goldfussi* Wedekind: Ibid., p. 74, figs. 106, 107.

Locality	Reg. No.	Pl.	Fig.	Annual Length
Auburg of Gerolstein in Eifel, Germany	(73)	13	2c	4.00

XIV. Genus **DIALYTOPHYLLUM** (Amanshauser) em. Wedekind 192464. **Dialytophyllum simplex** Wedekind

- 1924 *Dialytophyllum simplex* Wedekind: Das Mitteldevon der Eifel, T. II, p. 42, pl. 10, figs. 60, 61.

Locality	Author	Pl.	Fig.	Annual Length
Genna in Eifel, Germany	Wedekind	10	61	4.00

65. *Dialytophyllum cylindricum* (Schlüter)

Pl. XVI, Figs. 2a-c.

- 1889 *Mesophyllum cylindricum* Schlüter: Anthozoen des rheinischen Mitteldevon, p. 73, pl. VII, figs. 3, 4.
 1925 *Dialytophyllum secundum* Wedekind: Das Mitteldevon der Eifel, T. II, p. 42, pl. 10, fig. 62; pl. 17, fig. 106.

Locality	Author	Pl.	Fig.	Annual Length
Lissingen in Eifel, Germany	Schlüter	7	4	7.00
Genna in Eifel, Germany	Wedekind	17	106	7.00
Gerolstein in Eifel, Germany	(16)	16	2b, 2c	7.00

66. *Dialytophyllum multiseptatum* Ma (sp. nov.)

Pl. XIX, Figs. 1a-1g.

Locality	Reg. No.	Pl.	Fig.	Annual Length
Gerolstein in Eifel, Germany	(49094)	19	1, 1a, 1b	7.00

67. *Dialytophyllum pseudoorthoceras* (Schulz)

- 1883 *Actinocystis pseudoorthoceras* Schulz: Die Eifelkalkmulde von Hillesheim, p. 84, pl. II, figs. 3, 4.

Locality	Author	Pl.	Fig.	Annual Length
Nohn, Hillesheim, Germany	Schulz	2	3	11.00
„	„	2	4	11.00

68. *Dialytophyllum complicatum* Amanshauser

- 1925 *Dialytophyllum complicatum* Wedekind: Das Mitteldevon der Eifel, T. II, p. 43, pl. 10, fig. 63.
 1933 *Cyathophyllum Heraklei* Charles: Contribution a l'Etude des Terrains paléozoïques de l'Anatolie du Nord-Ouest (Asie Mineure), p. 132, pl. V, figs. 32, 34; pl. VI, fig. 33.

Locality	Author	Pl.	Fig.	Annual Length
Anatolia, Asia Minor	Charles	5	32	3.70

69. ***Dialytophyllum goldfussi*** (Edwards and Haime)

Pl. XVIII, Figs. 1a-c.

- 1886 *Actinocystis Goldfussi* Frech: Cyath. u. Zaphr., pp. 106-109.

Locality	Author	Pl.	Fig.	Annual Length
Gerolstein in Eifel, Germany	(49103)	18	1c	10.00
"	Frech	Textfig. in p. 106		9.00

XV. Genus **MESOPHYLLUM** Schlüter 1889

70. ***Mesophyllum maximum*** Schlüter

Pl. XIV, Figs. 1a-c; Pl. XV, Figs. 1a-c; Pl. XVI, figs. 1a-b.

- 1889 *Mesophyllum maximum* Schlüter: Anthozoen des rheinischen Mittel-Devon, p. 70, pl. VII, fig. 1.
 1900 *Mesophyllum maximum* var. *dammoniensis* Frech: Das Paläozoicum in Hocharmenien und Persien, p. 185, pl. XVII, figs. 3a-3d, 4.
 1926 *Mochlophyllum maximum* Vollbrecht: Die Digonophyllinæ aus dem unteren Mittel-Devon der Eifel, pl. XV, fig. 2.
 1931 *Cosmophyllum Dachsbergi* Wedekind und Vollbrecht: Dis Lytophyllidae des mittleren Mitteldevon der Eifel, pp. 100, 103, 109-111, pl. VII, figs. 8-10; pl. XXVII, figs. 1, 4; pl. XXVIII, figs. 1-6; pl. XXX, fig. 9a.
 1931 *Cosmophyllum* sp. Ibid., p. 99, pl. XXVI, figs. 1-4; pl. XXVII, fig. 3; pl. XXIX, fig. 2.
 1931 *Pseudocosmophyllum Geigeri* Wedekind und Vollbrecht: Ibid., pp. 94, 95, pl. XIX, figs. 1-4; pl. XX, fig. 2.
 1932 *Pseudocosmophyllum* sp. Ibid., p. 108, pl. XXXVIII, figs. 1-5; pl. XXXIII, figs. 2, 3.

Locality	Author	Pl.	Fig.	Annual Length
Gerolstein in Eifel, Germany	Wedekind & Vollbrecht	28	6	7.50
"	"	33	2	9.00
Hillesheim in Eifel, Germany	"	19	1	9.60
Gerolstein in Eifel, Germany	(175)	14	1b, 1c	9.50
Eifel in Germany	(872)	15	1a, 1b, 1c	4.50
Sadarak in Turan, Asia Minor	Frech	17	3c	4.00

71. *Mesophyllum defectum* Schlüter

- 1889 *Mesophyllum defectum* Schlüter: Anthozoen des rheinischen Mitteldevon, p. 75, pl. VII, fig. 2.
- 1925 *Mesophyllum defectum* Wedekind: Das Mitteldevon der Eifel T. II, p. 51, pl. 13, fig. 76.
- 1925 *Arcophyllum typus* Markov: Note sur *Arcophyllum*, un nouveau genre de coraux Rugosa, p. 57, pl. III, figs. 3, 5, 7.

Locality	Author	Pl.	Fig.	Annual Length
Western slope of Ural, Russia	Markov	3	3	15.00

72. *Mesophyllum parvum* (Markov)

- 1925 *Arcophyllum parvum* Markov: Note sur *Arcophyllum*, un nouveau genre de coraux Rugosa, p. 58, pl. III, figs. 8, 10.

Locality	Author	Pl.	Fig.	Annual Length
Western slope of Ural, Russia	Markov	3	10	12.00

73. *Mesophyllum* sp.

Pl. XVII, Figs. 1a-b.

Locality	Reg. No.	Pl.	Fig.	Annual Length
Gerolstein in Eifel, Germany	(174)	17	1a	7.00

XVI. Genus **DIPLOCHONE** Frech 1886

74. **Diplochone striata** Frech

1886 *Diplochone striata* Frech: Cyath. u. Zaphr., p. 106, pl. VII, fig. 2.

Locality	Author	Pl.	Fig.	Annual Length
Martenberg in Germany	Frech	7	2	9.00

75. **Diplochone amplexoides** Tschernyschew

1893 *Diplochone amplexoides* Tschernyschew: Die Fauna des unteren Devon am Ostabhange des Ural, p. 97, XIV, fig. 9.

Locality	Author	Pl.	Fig.	Annual Length
Bobrowka in eastern slope of Ural, Russia	Tschernyschew	14	9	25.00

76. **Diplochone intermedia** Tschernyschew

1893 *Diplochone intermedia* Tschernyschew: Die Fauna des unteren Devon am Ostabhange des Ural, p. 97, textfig. 6; pl. XIV, fig. 19.

Locality	Author	Annual Length
Tura in eastern slope of Ural, Russia	Tschernyschew Textfig. 6	15.00

XVII. Genus **CYSTIPHYLLUM** Lonsdale 1836

77. **Cystiphyllum pseudoseptatum** Schulz

Pl. XX, Fig. 1a-b.

- 1853 *Cystiphyllum vesiculosum* Edwards and Haime: British Fossil Corals, p. 234, pl. 56, figs. 1, 1a, 1b.
- 1883 *Cystiphyllum pseudoseptatum* Schulz: Die Eifelkalkmulde von Hillesheim, p. 86, pl. III, figs. 22-24.
- 1912 *Cystiphyllum vesiculosum* Mansuy: Etude géol. du Yun-nan Oriental, p. 49, pl. VIII, figs. 2a, 2b.
- 1925 *Lythophyllum pseudoseptatum* Wedekind: 'Das Mitteldevon der Eifel, T. II, p. 34, pl. 8, figs. 49, 50, 52.

- 1931 *Lytophyllum pseudoseptatum* Wedekind und Vollbrecht: Die Lytophyllidæ des mittleren Mitteldevon der Eifel, pp. 90, 101-104, pl. VIII, Figs. 9, 10.

Locality	Author	Pl.	Fig.	Annual Length
Torquay in England	Edwards & Haime	56	1	6.00
Mudstone Bay in England	„	56	1b	5.00
Hillesheim, Germany	Schulz	2	4	4.00
Niederehe in Hillesheim, Germany	Wedekind	8	52	3.50
Hillesheim, Germany	Wedekind & Vollbrecht	8	10	3.20
Gerolstein in Eifel, Germany	(102)	20	1b	6.00
Po-si in Yunnan, Southern China	Mansuy	8	2a	No seasonal change

78. *Cystiphyllum vesiculosum* (Goldfuss)

Pl. XVII, Figs. 2a-b; Pl. XX, Figs. 2a-b, 3; Pl. XXI, Figs. 1a-b.

- 1826 *Cyathophyllum vesiculosum* Goldfuss (pars): Petr. Germ., T. 1, p. 58, pl. XVII, figs. 5a, 5c, 5d.
- 1887 *Cystiphyllum vesiculosum* Tschernyschew: Die Fauna des mittleren und oberen Devon an West-Abhänge des Urals, p. 120, pl. IV, figs. 21-22.
- 1892 *Cystiphyllum americanum* var. *australasica* Jack and Etheridge: Geology and Palæontology of Queensland and New Guinea, p. 58, pl. III, figs. 13, 14.
- 1894 *Cystiphyllum americanum* Keyes: Missouri Geol. Surv., Vol. IV, p. 117, pl. XIV, figs. 4a, 4b.
- 1901 *Cystiphyllum vesiculosum* Peetz: Beitr. z. Kenntnis der Fauna aus den devonischen Schichten am Randes des Steinkohlenbassins von Kusnetz, p. 380, pl. I, figs. 14a, 14b.
- 1912 *Cystiphyllum americanum* Mansuy: Etude géol. du Yun-nan Oriental, p. 50, pl. VIII, figs. 3a, 3b, 3c.
- 1925 *Lytophyllum tabulatum* Wedekind: Das Mitteldevon der Eifel, T. II, p. 34, pl. 7, figs. 38, 39.
- 1925 *Lytophyllum striatum* Wedekind: Ibid., p. 34, pl. 6, fig. 36; pl. 7, fig. 40.
- 1931 *Lytophyllum acuminatum* Wedekind und Vollbrecht: Die Lytophyllidæ des mittleren Mitteldevon der Eifel, pp. 84, 85, pl. I, figs. 1-3.
- 1931 *Lytophyllum conoideum* Idem.: Ibid., pp. 84-86, pl. II, figs. 1-3.

- 1931 *Lytophyllum corneolum* Idem.: Ibid., pp. 88-89, pl. I, figs. 4-6; pl. IV, figs. 8-9; pl. VI, figs. 1-6; pl. VII, figs. 1-7; pl. VIII, figs. 1-8; pl. IX, figs. 1-6; pl. XVII, fig. 6.
- 1931 *Lytophyllum curvulum* Idem.: Ibid., p. 93, 102-104, pl. XVI, figs. 1-4.
- 1931 *Lytophyllum eximium* Idem.: Ibid., pp. 101-104, pl. X, figs. 1-3.
- 1931 *Lytophyllum gracile* Idem.: Ibid., pp. 84-86, pl. II, figs. 4-6.
- 1931 *Lytophyllum fraternum* Idem.: Ibid., pp. 105-113, pl. XVI, figs. 5-9.
- 1931 *Lytophyllum solidum* Idem.: Ibid., pp. 91, 101-104, pl. X, figs. 5-9; pl. XI, figs. 1-3; pl. XIII, figs. 1-5; pl. XIV, figs. 1-4.

Locality	Author	Pl.	Fig.	Annual Length
Sserpeewka in western slope of Ural, Russia	Tscherny- schew	4	21b	13.00
Kusnetzk in Siberia	Peetz	1	14a	8.00
Winfield (Lincoln county), Missouri State, U. S. A.	Keyes	14	4a	6.00
"	"	14	4b	5.00
Eighteen Mile Creek, New York, U. S. A.	(64)	20	3	10.00
Po-si in Yunnan, Southern China	Mansuy	8	3a, 3b	8.50
Eifel, Germany	Goldfuss	17	5d	5.00
Gerolstein in Eifel, Germany	Wedekind	7	39	4.00
"	(513)	21	1b	6.60
"	(101)	20	2a	11.00
Hillesheim in Eifel, Germany	Wedekind & Vollbrecht	1	3	8.00
"	"	2	3	4.80
"	"	2	6	6.40
"	"	6	2	6.40
"	"	6	6	6.00
"	"	9	2	7.20
"	"	9	5	6.40
"	"	10	3	6.80
"	"	12	2	8.00
"	"	12	4	6.00

"	"	13	2	5.60
"	"	14	3	5.60
"	"	16	4	6.00
Queensland in Australia	Jack & Etheridge	3	13	7.00

79. *Cystiphyllum salairicum* Peetz

1901 *Cystiphyllum salairicum* Peetz: Beitr. z. Kenntnis der Fauna aus den devonischen Schichten am Rande des Steinkohlenbassins von Kusnetz, p. 381, pl. II, figs. 10a-c.

Locality	Author	Pl.	Fig.	Annual Length
Kusnetz in Siberia	Peetz	2	10a	12.50
"	"	2	10c	12.00

80. *Cystiphyllum nesterowskii* (Peetz)

1901 *Microplasma Nesterowskii* Peetz: Beitr. z. Kenntnis der Fauna aus den devonischen Schichten am Rande des Steinkohlenbassins von Kusnetz, p. 381, pl. I, figs. 15a-c.

Locality	Author	Pl.	Fig.	Annual Length
Kusnetz in Siberia	Peetz	1	15a	15.00

81. *Cystiphyllum cristatum* Frech

1886 *Cystiphyllum cristatum* Frech: Cyath. u. Zaphr., p. 108, pl. VIII, figs. 17, 26.

1893 *Cystiphyllum cristatum* Tschernyschew: Die Fauna des unteren Devon am Ostabhange des Ural, p. 96, pl. XIV, fig. 18.

Locality	Author	Pl.	Fig.	Annual Length
Petropawlowsk in Eastern Ural	Tschernyschew	14	18	No seasonal change
Gerolstein in Eifel, Germany	(Textfig.)			13.00

82. **Cystiphyllum conifollis** Hall

Pl. XVIII, Figs. 2a-b.

Locality	Reg. No.	Pl.	Fig.	Annual Length
Eighteen Mile Creek, New York				
State, U. S. A.	(99)	18	2a	14.50
"	(99)			12.00
"	(99)			15.00
"	(99)			9.00
"	(99)			10.00
"	(99)			15.00
"	(99)			11.00
"	(99)			15.00
"	(99)			10.00
"	(99)			15.00

83. **Cystiphyllum fasciculatum** Swartz

1913 *Cystiphyllum fasciculatum* Swartz: Devonian (Lower), p. 206, pl. XXI, figs. 7-9.

Locality	Author	Pl.	Fig.	Annual Eength
Cumberland in Maryland State, U.S.A.	Swartz	21	7	13.00

For the purpose of reference the measurement of the annual length in growth of the species cited above from various countries is average in the following table.



IV. SUMMARY

In the recent reef building corals the annual length of growth of corallum or corallites in the same species or in the same genus is longer in warmer places where the animals lived; this may have also been true in the case of Palæozoic corals. The water temperature in the Eurasian Continent as is indicated by the Devonian corals, and based upon the facts cited above may have been warmest along the zone combining the districts of Timan and Ural, Northern Russia and the provinces of Szechuan and Yunnan, Southern China. Measurements of the forms in the genera *Disphyllum*, *Macgeea*, *Prismatophyllum*, *Endophyllum*, *Ceratophyllum*, *Grypophyllum*, *Keriophyllum*, *Dohmophyllum* as well as *Diplochone* together with *Cystiphyllum* indicate that the temperature of the Devonian seas of Germany and France as well as England may have been much colder than those cited above and Kusnetzki of Siberia, Chitral and Northern Shan States of India. From the measurements of the same species or the forms of *Disphyllum*, *Endophyllum* and *Cystiphyllum* it is assumed that the temperature of the Devonian sea of England may have been more or less warmer than those of Germany and France, and that, that of Graz in Austria may have been somewhat colder than in Germany; from those of *Prismatophyllum quadrigeminum* (Goldfuss) and *Ceratophyllum ceratites* (Goldfuss) it seems that the temperature of the Devonian sea of France may have been more or less warmer than that of Germany. From the growth rate of the forms in *Macgeea* it is assumed that the Devonian seas of Chitral and Northern Shan States may have been much warmer than that in Germany of Europe and that in Central Iowa of North America. From the development of the seasonal change of growth in the forms of *Disphyllum*, *Ptenophyllum* and *Dialytophyllum* together with *Mesophyllum* it seems that the temperature of the Devonian seas of Anatolia and Turan of Asia Minor may have been much colder than that of Germany; from that of *Dohmophyllum tinocystis* (Frech) and its variety that the temperature of Italian sea during that time may have been colder than that in Germany. The development of the seasonal change of growth in *Campophyllum lindströmi* (Frech) and *Keriophyllum heterophylloides* (Frech) indicated that the temperature of sea water of Hunan and Kwangsi of Southern China in that time may have been much warmer than that of Germany. From the measurements of the forms of *Macgeea*, *Prismatophyllum*, *Pachyphyllum*, *Tabulophyllum* and *Campophyllum* as well as *Cystiphyllum* it seems

that the temperature of the Devonian seas of Iowa, Illinois and Missouri States of North America may have been neither colder nor so much warmer than that of Germany; from those of *Cystiphyllum* and *Keriophyllum* it is assumed that the temperature of the sea water of New York and Maryland States of North America may have been much warmer than that of Missouri as well as Germany during that time; and from that of *Tabulophyllum ellipticum* (Hall and Whitfield) it seems that the temperature of the Devonian sea in Mackenzie River Basin may have been much colder than that of Missouri State of North America.

These above mentioned data, advanced one step more, leads to the following inference.

V. DEVONIAN EQUATOR

This complicated subject cannot be discussed in the connection without drawing a rough map from the evidence cited above. As it was seen in the previous pages the phenomenon of the seasonal change of growth is quite wanting or very feeble in development in the fossils from Timan and Ural in Northern Russia and Szechuan and Yunnan in China, this is highly important and equally interesting as it probably indicated that the equator of the the earth during the Devonian period may passed near the districts just mentioned. It seems reasonable to assume that the positions of the fossil localities may have more or less migrated by later crustal movements of the earth and that the isothermal lines may have been, as at present-day, greatly influenced by various geographical conditions. From available data it follows that the equator may have, in the most probability, taken the course shown in the accompanying map during that time at the Eurasian Continent. Providing that this is allowed, then the North American Continent may have been nearer to the Eurasian Continent at that time than at present. Another important evidence which should be given is that the water temperature of the Devonian seas of New York and Maryland States of North America may have been much warmer than those of Missouri and Germany, and that the sea water of Germany may have been never much colder than those of Iowa, Illinois and Missouri, this lead the author to assume that the North American Continent may have never been in contact with Eurasia during the Devonian period as imagined by A. Wegener.¹⁾

1) Köppen und Wegener: Die Klimate der geologischen Vorzeit, pp. 141-144, fig. 21, 1924.

Devonian reef corals also occur in Australia and the seasonal change of growth in *Cystiphyllum* and *Grypophyllum* indicates that the Devonian sea of Queensland may have never been colder than that of Germany, but materials are insufficient to demonstrate whether or not the continent occupied its present position during the Devonian period.

At last the author wishes to express his sincere thanks to Professor H. Yabe under whose kind guidance this work was carried out. Thanks are also due to Mr. Y. S. Chi, geologist and palaeontologist of the Geological Survey of China, for sending photographs of the Devonian corals collected by himself from Central China; and to Mr. Kitora M. Hatai for his help in English.

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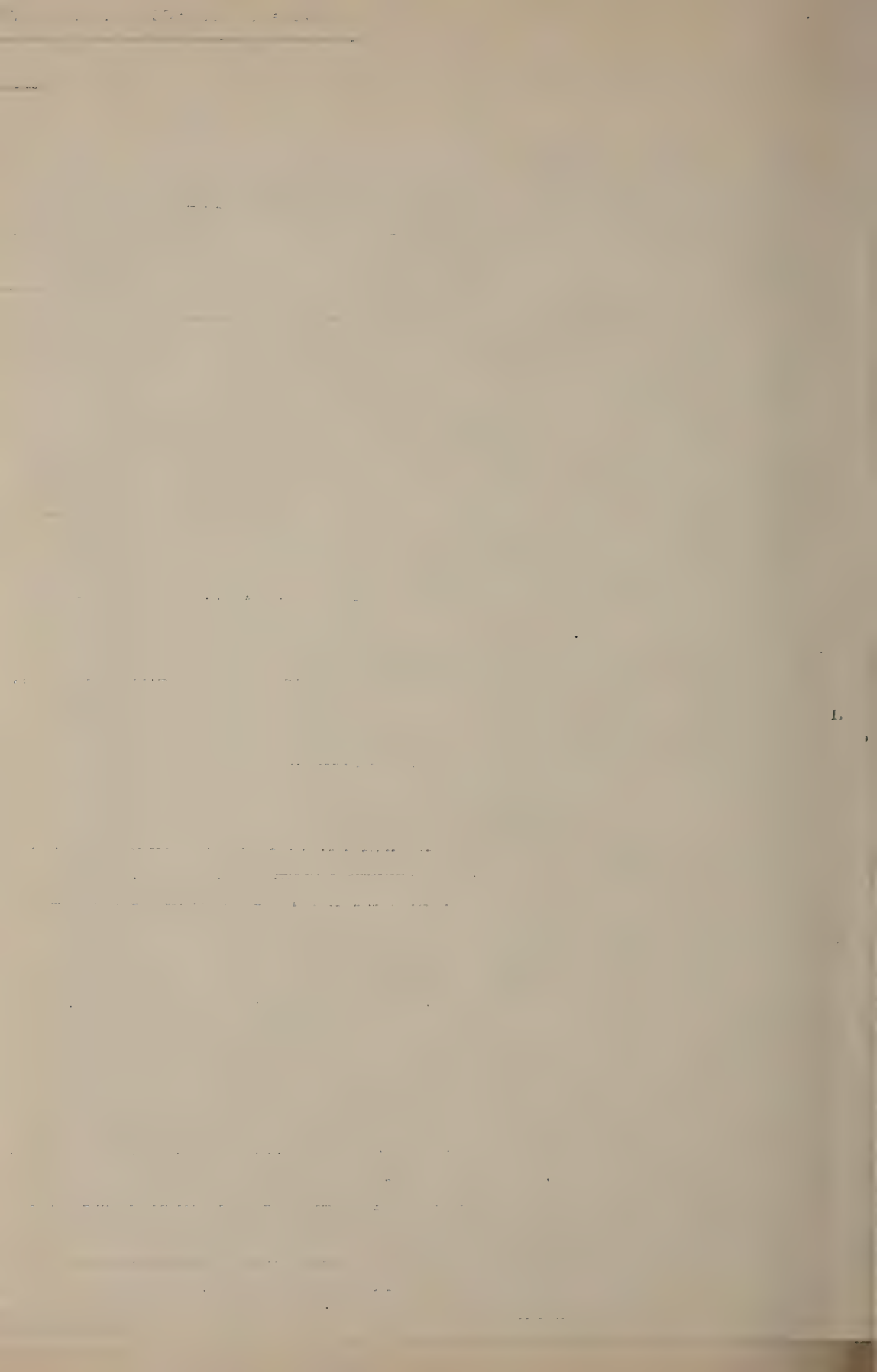
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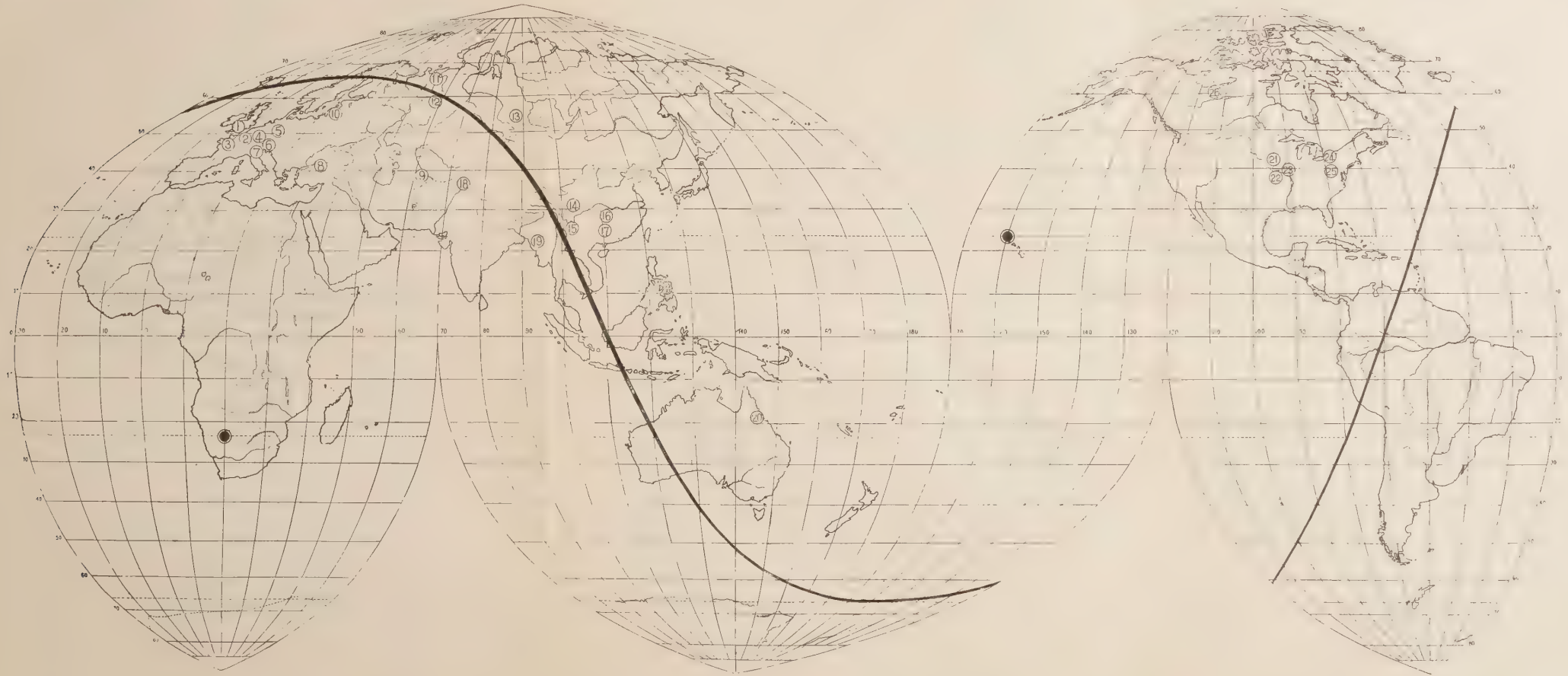


EXPLANATION OF MAP

————— Devonian Equator in Eurasia Continent and its prolongation.

● Position of pole in Devonian period. 1 Torquay of England. 2. Pas de Calais of France. 3. La Baconiere of France. 4. Eifel of Germany. 5. Harz of Germany. 6. Graz of Austria. 7. Collina of Italy. 8. Anatolia of Asia Minor. 9. Sadarak of Turan in Asia Minor. 10. Sserpeewka of western slope of Ural. 11. Timan of Northern Russia. 12. Tura of eastern slope of Ural in Northern Russia. 13. Kusnetzk of Siberia. 14. Ping-wu-hsien of prov. Szechuan, China. 15. Hsi-o and Po-si of prov. Yunnan, China. 16. Hsiang-hsiang-hsien of prov. Hunan, China. 17. Hsing-an-hsien of prov. Kwangsi, China. 18. Padaukpin of Northern Shan States, India. 18A. Chitral State of India. 19. North Central Iowa of North America. 20. Warsaw of Illinois State, North America. 21. Missouri of North America. 22. Buffalo and Eighteen Mile Creek of New York State, North America. 23. Cumberland of Maryland State, North America. 24. Hay River in Mackenzie River Basin of Canada, North America. 25. Queensland of Australia.

ACCOMPANYING MAP



EXPLANATION OF

PLATE I

(III) 53

EXPLANATION OF PLATE I.

- Figs. 1a-d. *Disphyllum goldfussi* (Geinitz). 2/1. (Middle Devonian).
Loc: South of Ping-i-pu, Ping-wu-hsien, Prov. Szechuan, China.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 6283.
- Fig. 2. *Disphyllum cæspitosum* (Goldfuss). 3/1. (Middle Devonian).
Loc: Gerolstein in Eifel, Germany.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49104.
- Figs. 3a-c. *Disphyllum supradevonicum* (Penecke). 2/1. (Middle Devonian).
Loc: Refrath, Germany.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49127.
- Figs. 4a-c. *Disphyllum kunthi* (Dames). 3/1. (Upper Devonian).
Loc: Schlesien, Germany.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. Krantz 10.



EXPLANATION OF

PLATE II

(III) 55

EXPLANATION OF PLATE II.

Figs. 1a-c. *Disphyllum minus* (Römer). Figs. 1a-b 2/1; fig. 1c 3/1. (Upper Devonian).

Loc: Iberg of Grund in Harz, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 91.

Figs. 2a-d. *Disphyllum cæspitosum* (Goldfuss). 6/7. (Middle Devonian).

Loc: Uchta River in Timan, Northern Russia (Reproduced from Lebedew's Plate IV, figs. 54-57).

Figs. 3a-b. *Prismatophyllum quadrigeminum* (Goldfuss). 2/1. (Middle Devonian).

Loc: Refrath in Köln, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 80.



EXPLANATION OF

PLATE III

(III) 57

EXPLANATION OF PLATE III.

Figs. 1a-b. *Prismatophyllum quadrigeminum* (Goldfuss). 2/1. (Middle Devonian).

Loc: Perques, Pas de Calais, France.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 13.

Figs. 2a-b. *Prismatophyllum goldfussi* (Ewdards and Haime). 2 1. (Middle Devonian).

Loc: Warsaw in Illinois State, North America.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 36501.

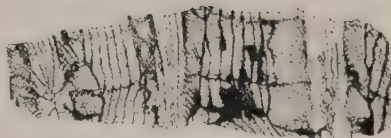
Figs. 3a-b. *Prismatophyllum sedgwicki* (Edwards and Haime). 2 1. (Middle Devonian).

Loc: Johnson county of Iowa State, North America.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 12.



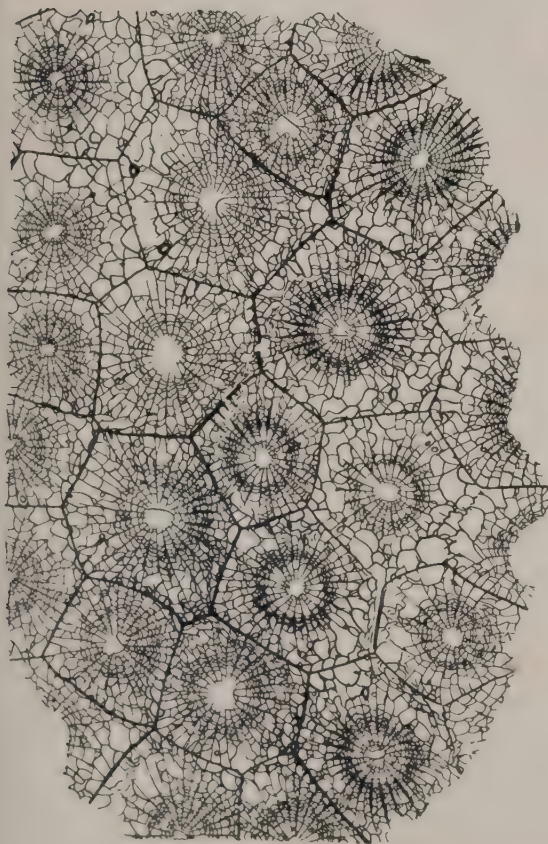
1a



2a



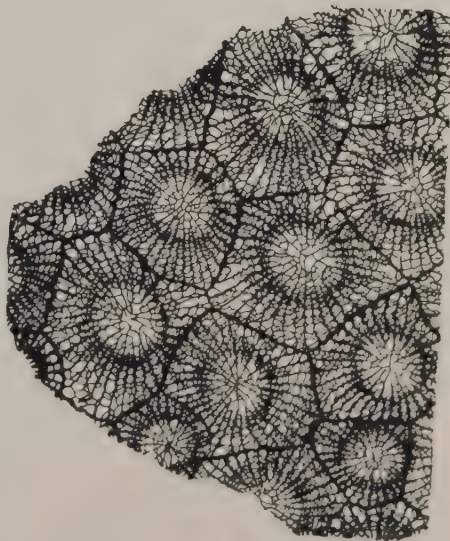
2b



1b



3a



3b

EXPLANATION OF

PLATE IV

EXPLANATION OF PLATE IV.

Figs. 1a-b. *Macgeea multizonata* (Reed). 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Figs. 2a-b. *Prismatophyllum? douvillei* var. *sinensis* (Yabe and Hayasaka). 2/1. (Middle Devonian).

Loc: Yang-liu-shu, Ta-kuan-ting, Prov. Yunnan, Southern China.

Figs. 3a-c. *Spongophyllum semiseptatum* Schlüter. 2/1. (Middle Devonian).

Loc: Sötenich in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49131.

Figs. 4-6c. *Ceratophyllum ceratites* (Goldfuss). 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

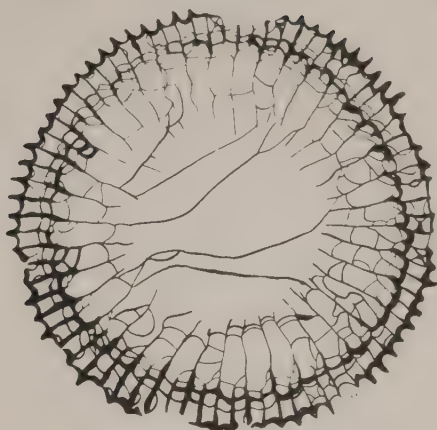
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 62.

Fig. 5b is a vertical section through periperal zone of the same corallum of Fig. 5a. Figs. 6a-c are serial cross sections of a same corallum.

3



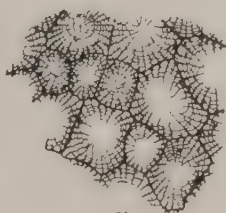
1a



1b



2a



2b



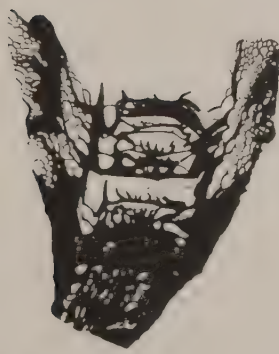
3a



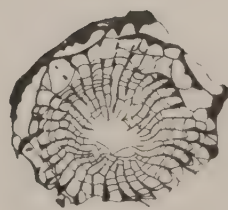
4



6a



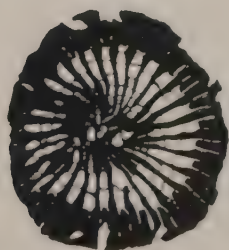
5a



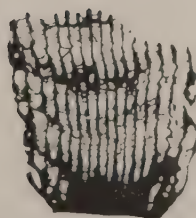
3b



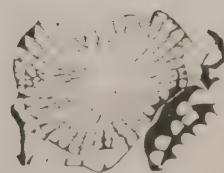
6b



6c



5b



3c

EXPLANATION OF

PLATE V

EXPLANATION OF PLATE V.

Figs. 1a-b. *Campophyllum dianthus* (Goldfuss). 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 84.

Figs. 2a-b. *Campophyllum dianthus* (Goldfuss). 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 83.



1a



2a



1b



2b

EXPLANATION OF

PLATE VI

(III) 63

EXPLANATION OF PLATE VI.

Figs. 1a-b. *Spongophyllum kunthi* Schlüter. 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 36499.

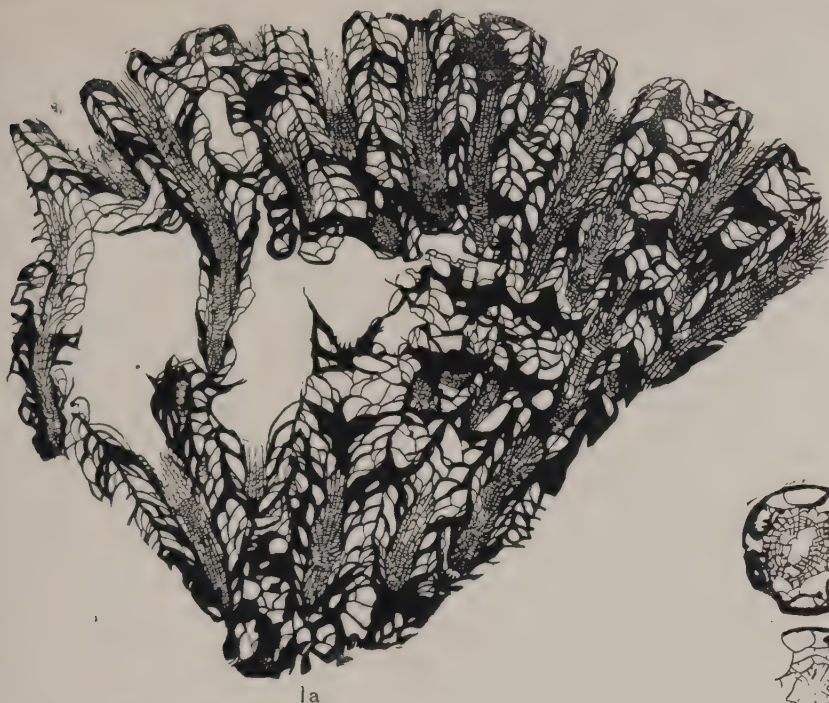
Figs. 2a-b. *Spongophyllum elongatum* Schlüter. 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 36500.

Figs. 3a-c. *Campophyllum annulatum* (Peetz). Natural size. (Middle Devonian).

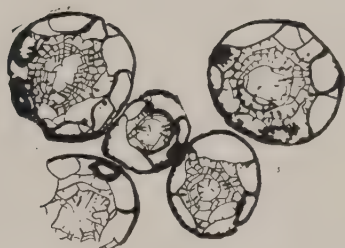
Loc: Ur River at Village Bedarewa, Kusnetzk, Siberia (Reproduced from Peetz's Plate 1, figs. 13a-c).



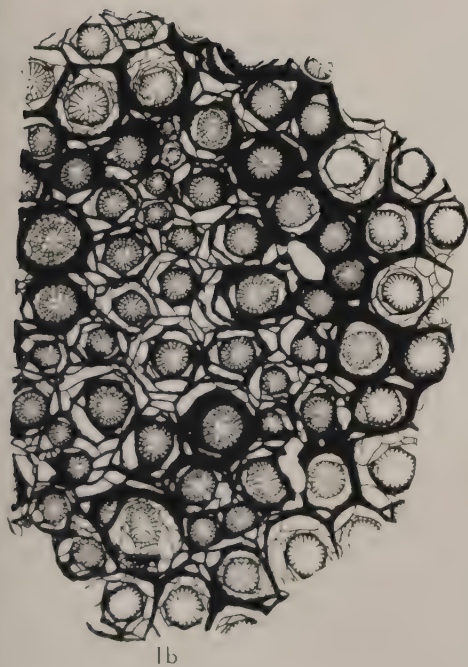
1a



2a



2b



1b



3b



3c



3a

EXPLANATION OF

PLATE VII

(III) 65

EXPLANATION OF PLATE VII.

Figs. 1a-e. *Ptenophyllum vermiculare* (Goldfuss). 2/1. (Middle Devonian).
Serial cross sections.

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49110.

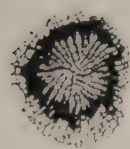
Figs. 2a-f. *Ptenophyllum vermiculare* (Goldfuss). 2/1. (Middle Devonian). b-f:
Serial cross sections.

Loc: Gerolstein in Eifel, Germany.

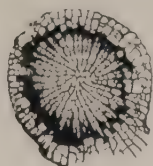
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49117.

Fig. 3. *Ptenophyllum heterophyllum* (Edwards and Haime). 2/1. (Middle Devonian).

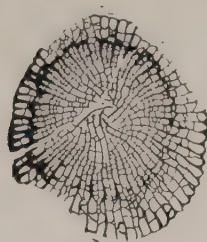
Loc: Gerolstein in Eifel, Germany.



1a



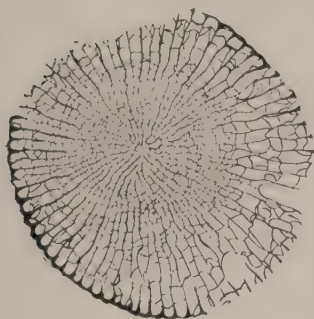
1b



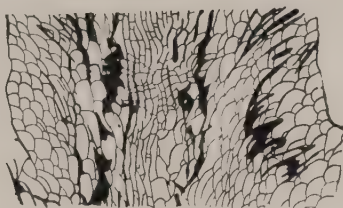
1c



1d



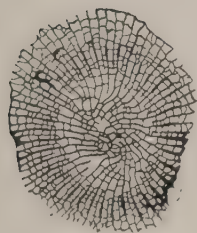
1e



2a



2b



2c



2d



2e



3



2f

EXPLANATION OF

PLATE VIII

(III) 67

EXPLANATION OF PLATE VIII.

Figs. 1a-i. *Ptenophyllum heterophyllum* (Edwards and Haime). 2/1. (Middle Devonian). 1a-g: Serial cross sections.

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49090.

Figs. 2a-b. *Ptenophyllum heterophyllum* (Edwards and Haime). 2 1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 79.



EXPLANATION OF

PLATE IX

(III) 69

EXPLANATION OF PLATE IX.

Figs. 1a-c. *Ptenophyllum heterophyllum* (Edwards and Haime). 2/1. (Middle Devonian). 1c: Vertical section through peripheral zone.

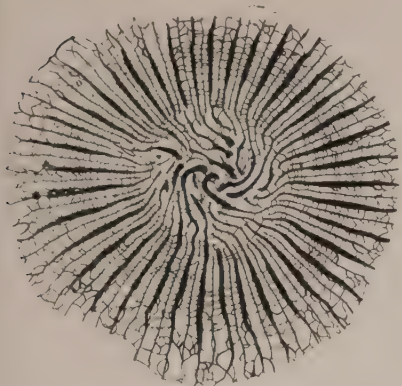
Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 75.

Figs. 2a-d. *Ptenophyllum heterophyllum* (Edwards and Haime). 2/1. (Middle Devonian).

Loc: Auburg in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 77.



1a



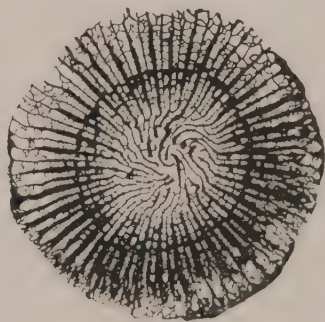
1b



1c



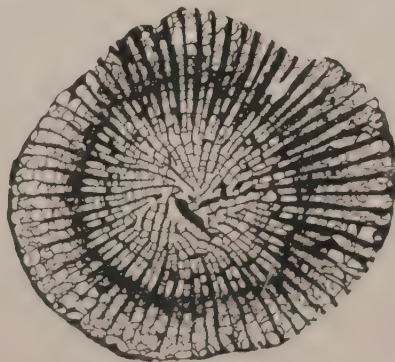
2b



2a



2d



2c

EXPLANATION OF

PLATE X

(III) 71

EXPLANATION OF PLATE X.

Figs. 1a-b. *Ptenophyllum heterophyllum* (Edwards and Haime). (Middle Devonian). Fig. 1a 19/10; Fig. 1b: Vertical section through most peripheral zone, 2/1.

Loc: Auburg of Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49089.

Figs. 2a-f. *Ptenophyllum heterophyllum* (Edwards and Haime). 2'1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49111.

Figs. 2a-d: Serial cross sections.



1a



2a



2b



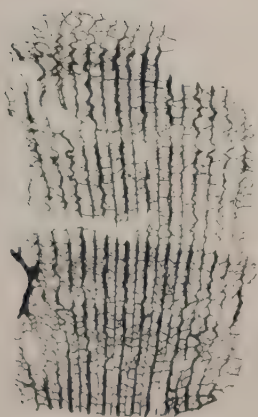
2c



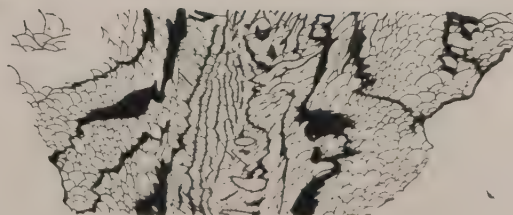
2d



2e



1b



2f

EXPLANATION OF
PLATE XI

EXPLANATION OF PLATE XI.

Figs. 1a-b. *Campophyllum lindströmi* (Frech). 2 1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 88.

Figs. 2a-e. *Ptenophyllum heterophyllum* (Edwards and Haime). 2 1. (Middle Devonian). Serial cross sections.

Loc: Auburg of Gerolstein in Eifel, Germany.

Figs. 3a-b. *Grypophyllum* sp. 6/7. (Middle Devonian).

Loc: Petsch. Pishma, Timan of Northern Russia. (Reproduced from Lebedew's Plate V, Figs. 59, 60).

Figs. 4a-e. *Grypophyllum timanicum* (Lebedew). 6 7. (Middle Devonian).

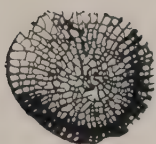
Loc: Uchta River in Timan, Northern Russia. (Reproduced from Lebedew's Plate V, figs. 64-66).



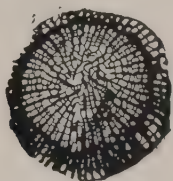
1a



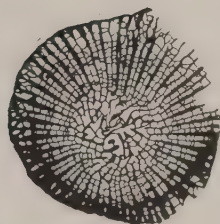
1b



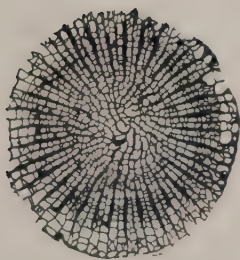
2a



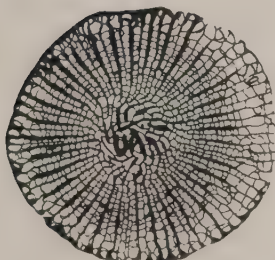
2b



2c



2d



2e



3a



4a



4b



4c

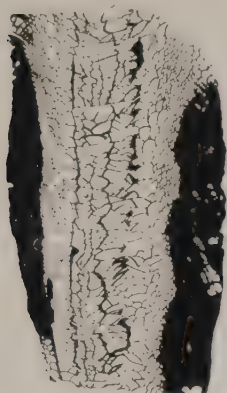


3b

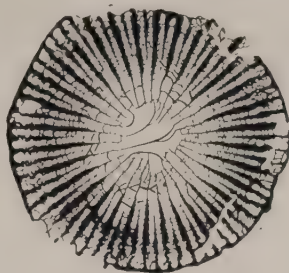
EXPLANATION OF
PLATE XII

EXPLANATION OF PLATE XII.

- Figs. 1a-d. *Keriophyllum heterophylloides* (Frech). 2/1. (Middle Devonian).
Loc: Lao-cha-ting, Hsing-an-hsien, prov. Kwangsi, China.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 6284.
Fig. 1d: Vertical section of peripheral zone.
- Figs. 2a-b. *Keriophyllum* sp. 2/1. (Middle Devonian).
Loc: Auburg of Gerolstein in Eifel, Germany.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49108.
- Figs. 3a-b. *Keriophyllum proliferum* (Frech). (Middle Devonian).
Loc: Buffalo in New York State, North America. Fig 3a 3/2; 3b 2/1.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 92.



1c



1a



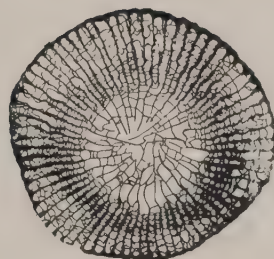
1d



2a



1b



2b



3a



3b

EXPLANATION OF

PLATE XIII

(III) 77

EXPLANATION OF PLATE XIII.

Fig. 1. *Dohmophyllum helianthoides* (Goldfuss). 2/ 1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 71.

Figs. 2a-c. *Dohmophyllum involutum* Wedekind. (Middle Devonian).

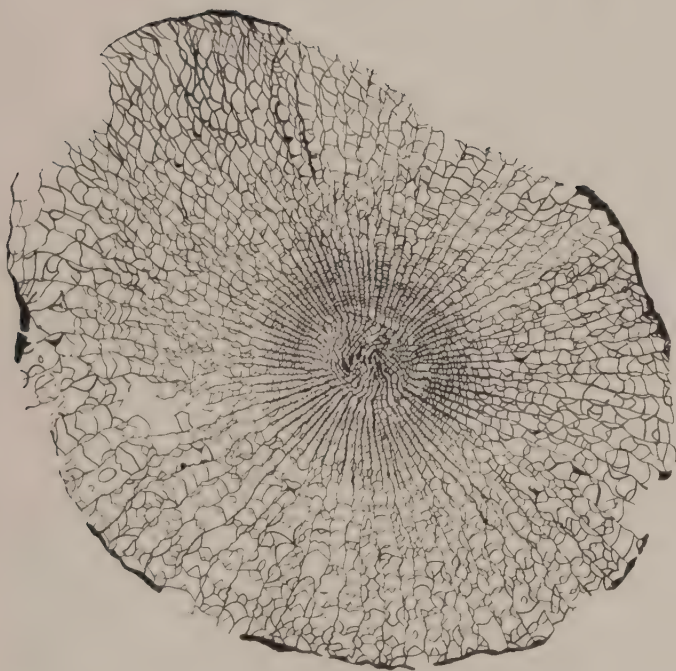
Loc: Auburg of Gerolstein in Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 73.

Figs. 2a and 2b 3/2; 2c 2/1.



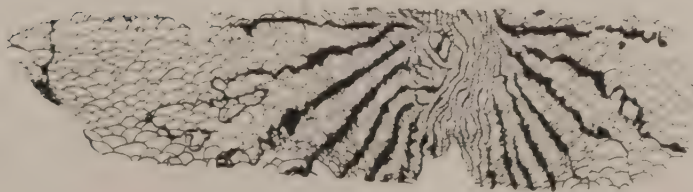
1



2b



2a



2c

EXPLANATION OF

PLATE XIV

(III) 79

EXPLANATION OF PLATE XIV.

Figs. 1a-c. *Mesophyllum maximum* Schlüter. (Middle Devonian).

Fig. 1a 9/5; Figs. 1b-c. 3/2.

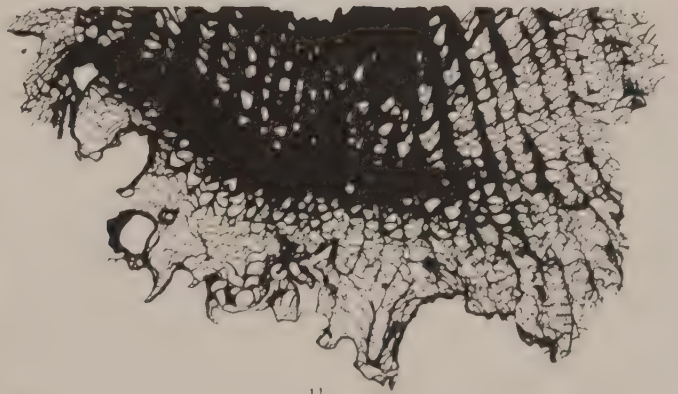
Loc: Gerolstein in Eifel, Germany.

Inst Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 175.

Fig. 1c: Vertical section of peripheral zone.



1a



1b



1c

EXPLANATION OF

PLATE XV

(III) 81

EXPLANATION OF PLATE XV.

Figs. 1a-c. *Mesophyllum maximum* Schlüter. (Middle Devonian).

Serial vertical sections. Figs. 1a-b 3/2; Fig. 1c 2/1.

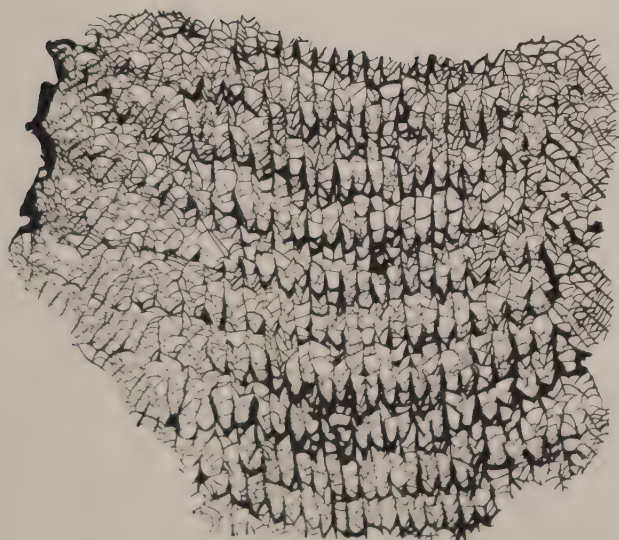
Loc: Eifel, Germany.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 872.

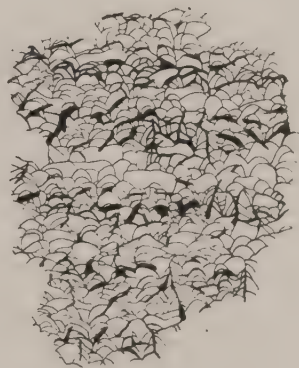
Fig. 1c: Vertical section near epitheca.



1a



1b



1c



EXPLANATION OF

PLATE XVI

(III) 83

EXPLANATION OF PLATE XVI.

Figs. 1a-b. *Mesophyllum maximum* Schlüter. 3/2. (Middle Devonian).

Cross sections of Plate XV, Figs. 1a-c.

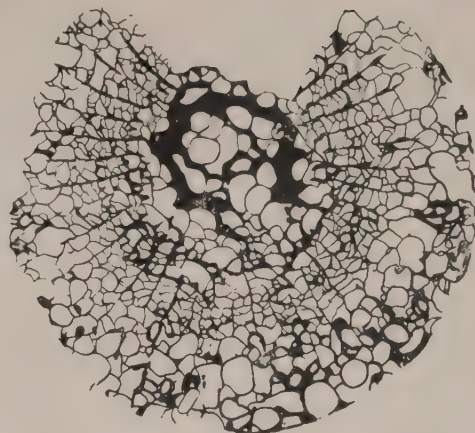
Figs. 2a-c. *Dialytophyllum cylindricum* (Schlüter). 2 1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

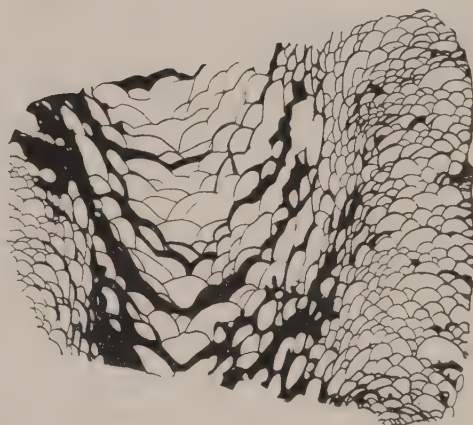
Inst Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 16.



1a



2a



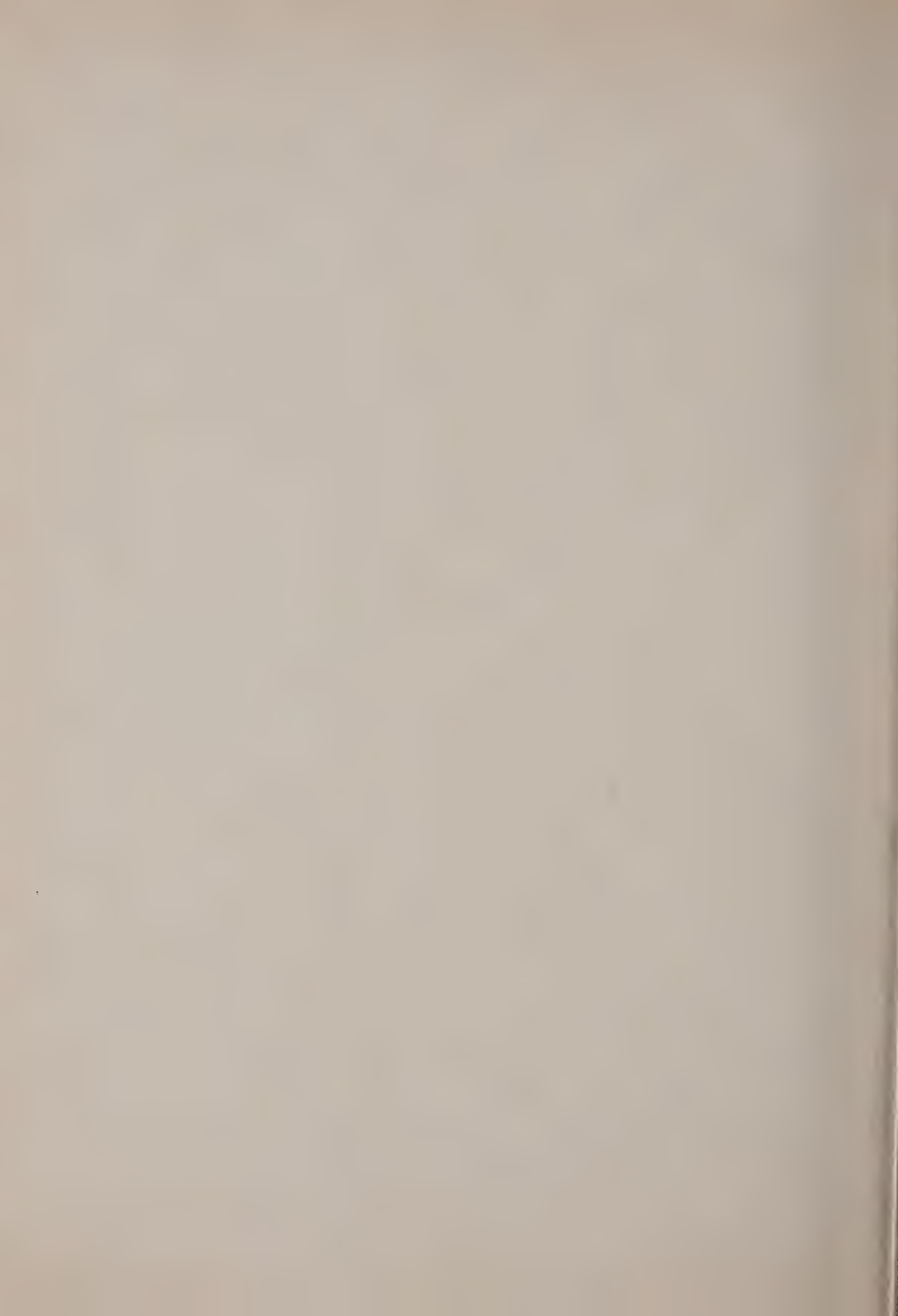
2b



1b



2c



EXPLANATION OF

PLATE XVII

(III) 85

EXPLANATION OF PLATE XVII.

Figs. 1a-b. *Mesophyllum* sp. 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

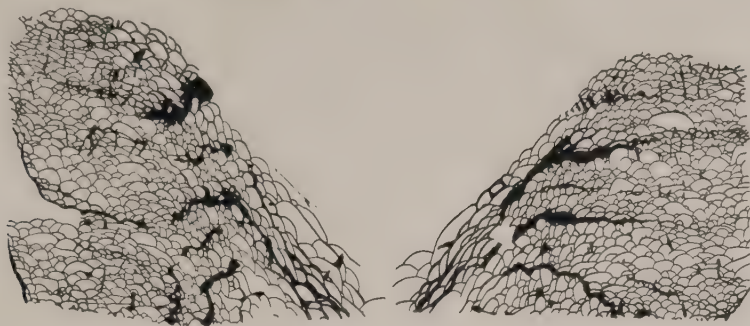
Inst Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 174.

Figs. 2a-b. *Cystiphyllum vesiculosum* (Goldfuss). Natural size. (Middle Devonian).

Loc: Tomi-Tschumysch River in Felsen Bazar, Kusnetz, Siberia. (Photographic reproduction of Peetz's Plate I, figs. 14a-b).

Figs. 3a-b. *Spongophyllum stuckenbergi* (Lebedew). 6/7. (Middle Devonian).

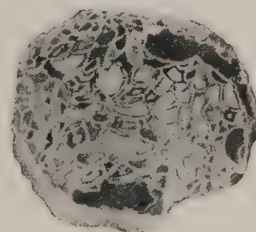
Loc: Uchta River in Timan, Northern Russia. (Reproduced from Lebedew's Plate II, figs. 22-24).



1a



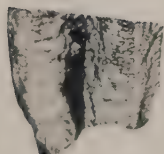
1b



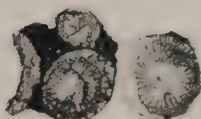
2a



2b



3a



3b

EXPLANATION OF

PLATE XVIII

(III) 87

EXPLANATION OF PLATE XVIII.

Figs. 1a-c. *Dialytophyllum goldfussi* (Frech). 2/1. (Middle Devonian).

Loc: Gerolstein in Eifel, Germany.

Inst Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49103.

Figs. 2a-b. *Cystiphyllum conifollis* Hall 2/1. (Middle Devonian).

Loc: Eighteen Mile Creek, New York State, North America.

Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 99.



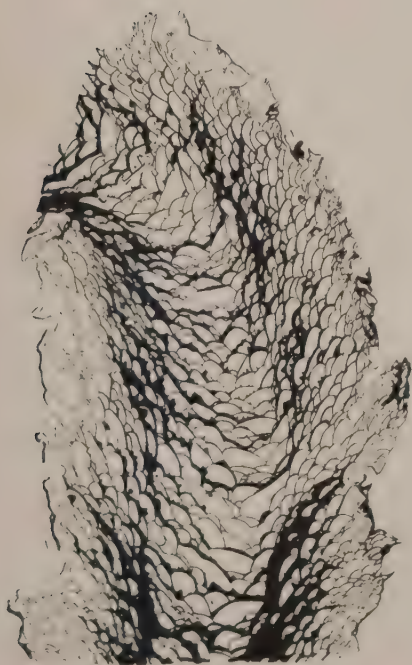
1a



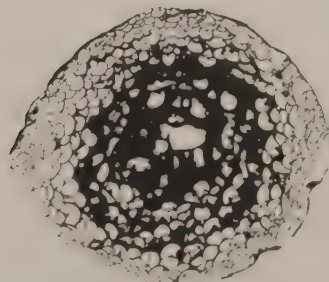
1b



1c



2a



2b

EXPLANATION OF

PLATE XIX

(III) 89

EXPLANATION OF PLATE XIX.

Figs. 1a-g. *Dialytophyllum multiseptatum* Ma. 2/1. (Middle Devonian).

Fig. 1a-c: Vertical serial sections; Figs. 1d-g: Cross serial sections.

Loc: Gerolstein in Eifel, Germany.

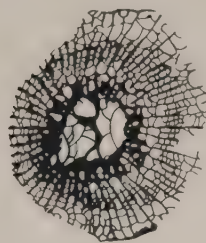
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 49094.

Figs. 2a-c. *Endophyllum keyserlingi* (Lebedew). 6/7. (Middle Devonian).

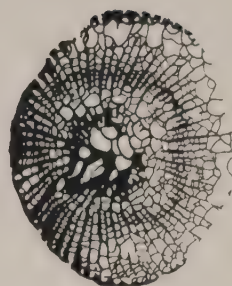
Loc: Uchta River in Timan, Northern Russia. (Reproduced from Lebedew's Plate V, figs. 67-69).



1a



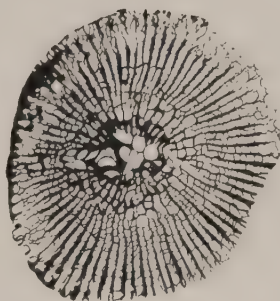
1d



1e



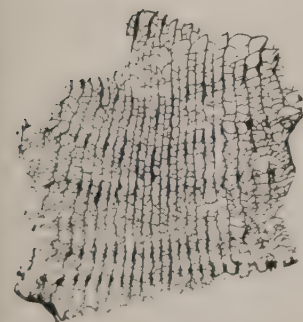
1b



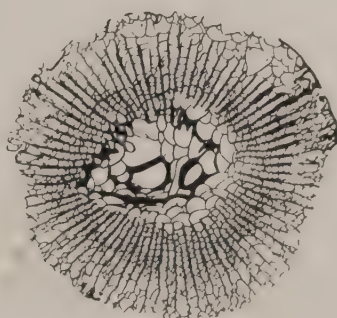
1f



2a



1c



1g



2b



2c

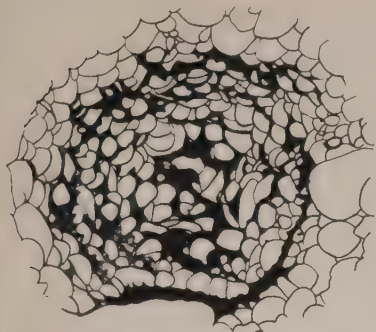
EXPLANATION OF

PLATE XX

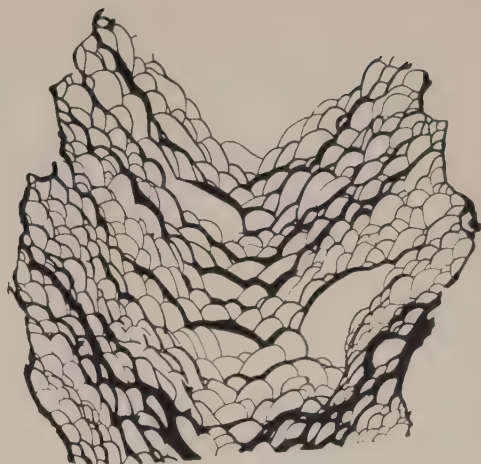
(III) 91

EXPLANATION OF PLATE XX.

- Figs. 1a-b. *Cystiphyllum pseudoseptatum* Schulz. 2 '1. (Middle Devonian).
Loc: Gerolstein in Eifel, Germany.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 102.
- Figs. 2a-b. *Cystiphyllum vesiculosum* (Goldfuss). 2 '1. (Middle Devonian).
Loc: Auburg of Gerolstein in Eifel, Germany.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 101.
- Fig. 3. *Cystiphyllum vesiculosum* (Goldfuss). 2 '1. (Middle Devonian).
Loc: Eighteen Mile Creek, New York State, North America.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 64.



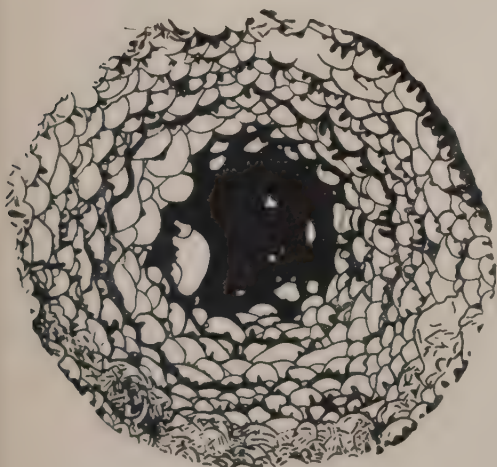
1a



1b



2a



2b



3

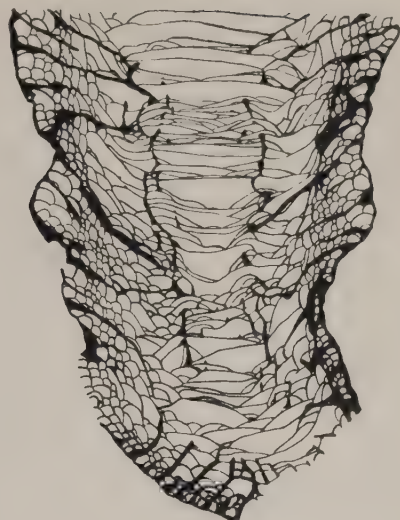
EXPLANATION OF
PLATE XXI

EXPLANATION OF PLATE XXI.

- Figs. 1a-b. *Cystiphyllum vesiculosum* (Goldfuss). 2/1. (Middle Devonian).
Loc: Gerolstein in Eifel, Germany.
Inst. Geol. & Palæont. Tôhoku Imp. Univ. Reg. No. 513.
- Fig. 2. *Campophyllum lindströmi* (Frech). 2/1. (Middle Devonian).
Loc: Chi-tsu-chiao, Hsiang-hsiang-hsien, prov. Hunan, China.
Geol. Surv. China Reg. No. D 16, 2412.
- Fig. 3. *Campophyllum lindströmi* (Frech). 2/1. (Middle Devonian).
Loc: Chi-tsu-chiao, Hsiang-hsiang-hsien, prov. Hunan, China.
Geol. Surv. China Reg. No. D 16, 2190.



1a



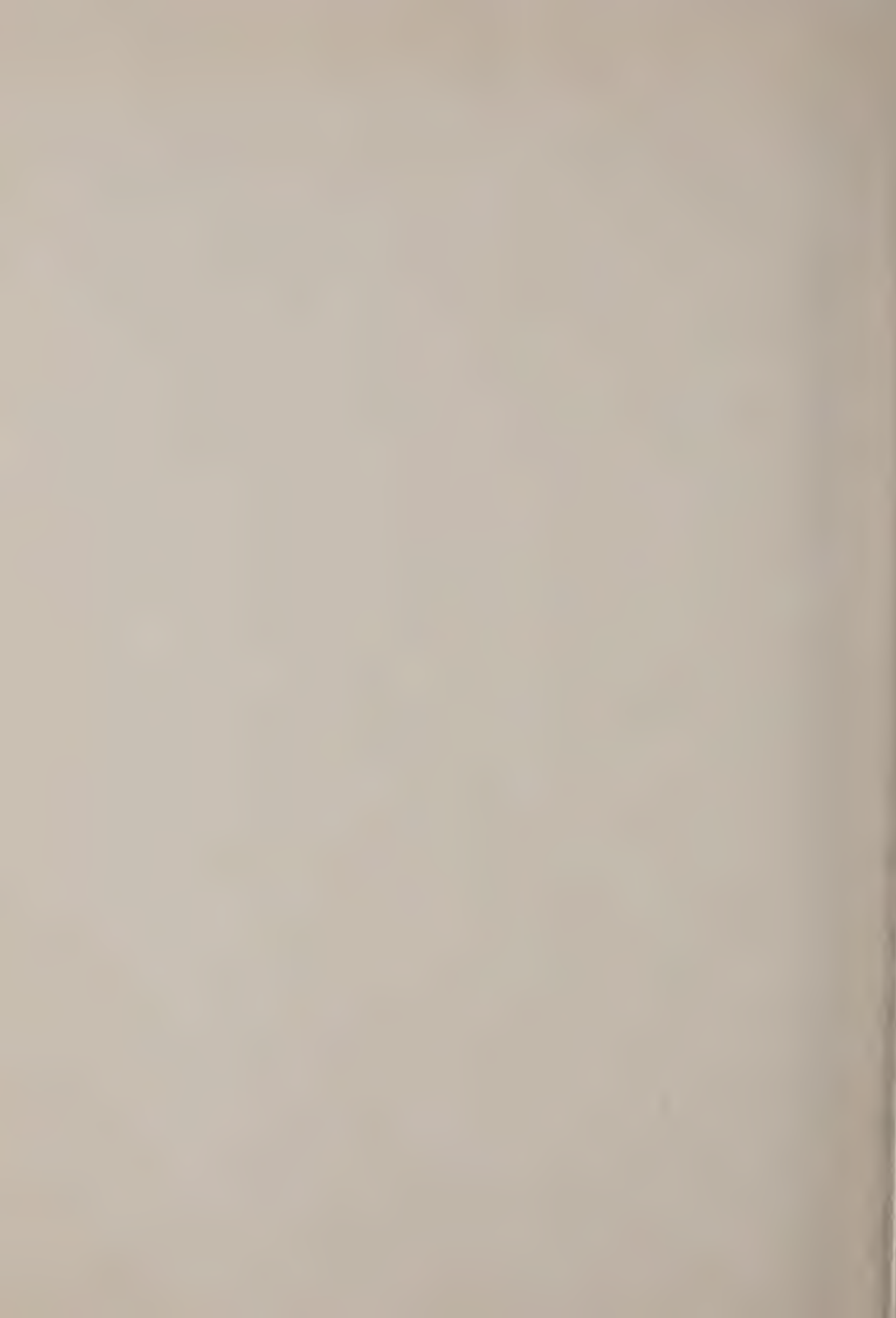
2



1b



3



EXPLANATION OF

PLATE XXII

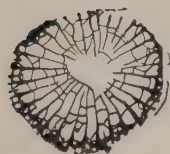
(III) 95

EXPLANATION OF PLATE XXII.

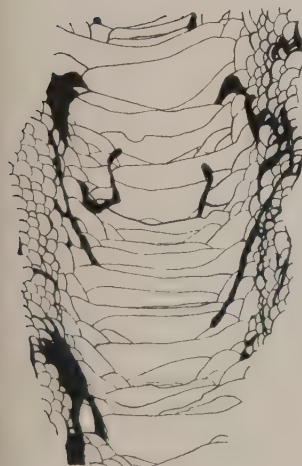
- Figs. 1a-b. *Campophyllum* cf. *lindströmi* (Frech). 2/1. (Middle Devonian).
Loc: Chi-tsu-chiao, Hsiang-hsiang-hsien, prov. Hunan, China.
Geol. Surv. China Reg. No. D 16, 2367.
- Figs. 2a-b. *Campophyllum* cf. *lindströmi* (Frech). 2/1. (Middle Devonian).
Loc: Chi-tsu-chiao, Hsiang-hsiang-hsien, prov. Hunan, China.
Geol. Surv. China Reg. No. D 16, 2426.
- Figs. 3a-b. *Campophyllum* cf. *lindströmi* (Frech). 2 1. (Middle Devonian).
Loc: Chi-tsu-chiao, Hsiang-hsiang-hsien, prov. Hunan, China.
Geol. Surv. China Reg. No. D 16, J.
- Figs. 4a-b. *Campophyllum* cf. *lindströmi* (Frech). 2 1. (Middle Devonian).
Loc: Chi-tsu-chiao, Hsiang-hsiang-hsien, prov. Hunan, China.
Geol. Surv. China Reg. No. D 16, 2204.



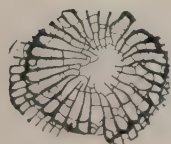
1a



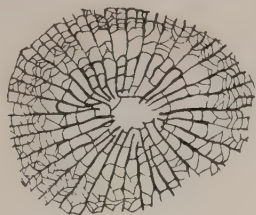
1b



3a



4b



2a



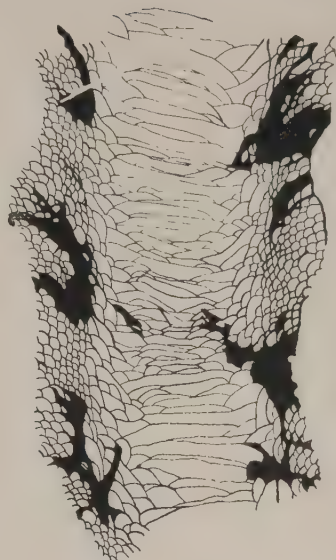
2b



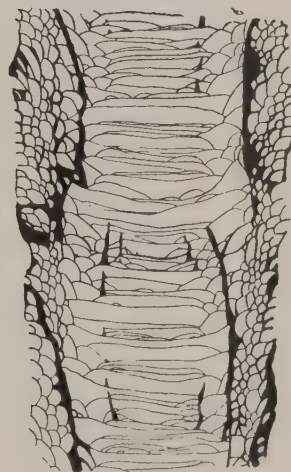
3b



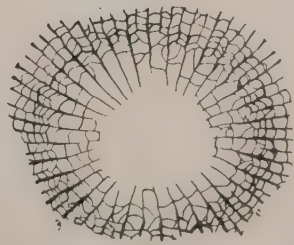
4c



2c



4a



4d

可推想到美國 New York 與 Maryland 兩省在泥盆紀時其海水溫度當高於 Missouri 省與德國。由 *Tabulophyllum ellipticum* (Hall and Whitfield) 的成長率，可以看出 Mackenzie River 盆地在泥盆紀時必更寒於 Missouri 省。由以上所得之結果，可進一步得下列之結論。

泥盆紀的赤道

對於這個複雜的問題，用以上有限的材料只能論其大概。如上所述，在歐亞兩洲，中國雲南四川等省與俄國的 Ural 及 Timan 一帶，珊瑚化石成長上的季候變化現象，完全缺如或發達極弱，這不外表示當時的赤道通過這一帶或近於這一帶。上列產化石的諸地點，因受以後的地殼運動，自應略變其原來位置，而且等溫線也大概與現在一樣，要受地理環境的影響，不過在大體上，由以上的材料，可以推想當時的赤道，在歐亞大陸，大概不至離附圖上所繪的線很遠，若然，則當時的北美大陸與歐亞大陸較現在當更形接近。此外有一點頗耐人尋味者即美國 New York 與 Maryland 兩省泥盆紀的海水溫度高於 Missouri 省與德國，而德國當時的海溫又不甚低於美國 Iowa, Illinois, Missouri 諸省，由此可以推知歐美兩大陸在當時似非如 A. Wegener 教授所想像之兩相聯接。

澳洲在泥盆紀是否占有現在之位置，因為缺乏材料，無從推論，只就 *Grypophyllum* 與 *Cystiphyllum* 成長上的季候變化發達之情形而論，Queensland 當不至比德國更冷。

最後對於矢部長克教授的懇切指導、實業部地質調查所計榮森先生的中國材料之供給與畑井小虎君的英文修正，著者敬表十二分謝意。

樣現象，大概亦表示同樣性質，我們由同種或屬的珊瑚化石之成長率，可以比較追究各地水溫之高低。考究泥盆紀四射珊瑚化石的結果（詳見英文與別表）如下：

在歐亞兩洲，以中國雲南四川等省與俄國 Ural 及 Tiran 諸處一帶珊瑚化石成長上的季候變化之現象，發達最弱，或完全缺如，由此可以想見當時此等地方氣候最暖。由 *Disphyllum*, *Macgea*, *Prismatophyllum*, *Endophyllum*, *Ceratophyllum*, *Grygophyllum*, *Spongophyllum*, *Dohmophyllum*, *Mesophyllum*, *Diplochone*, *Cystiphyllum* 等屬成長上之季候變化發達的情形與長成率推論之，則英、德、法各地之泥盆紀海水溫度當低於上列各地與西伯利亞之 Kuznetzk 與印度之 Chitral 及 Northern Shan States 由 *Disphyllum*, *Prismatophyllum*, *Endophyllum*, *Ceratophyllum* 與 *Cystiphyllum* 各屬中同種的成長率看起來，英國泥盆紀海水溫度當略高於德、法兩國，而法國又比德國微暖。由 *Disphyllum*, *Tabulophyllum*, *Ptenophyllum*, *Dialgtophyllum*, *Mesophyllum* 各種類成長上的季候變化發達的情形與成長率，可以推知小亞細亞之 Anatolia 與 Turan 等處之泥盆紀海水溫度當較德國各地為低；由 *Dohmophyllum tinocystis* (Frech) 與其變種，不難推想到意大利之泥盆紀必寒於德國。看 *Campophyllum lindstroemi* (Frech) 與 *Keriphyllum heterophyllioides* (Frech) 成長上的季候變化發達的情形，中國廣西與湖南一帶的泥盆紀海當更暖於德國各地。在北美洲，由 *Macgea*, *Prismatophyllum*, *Pachyphyllum*, *Tabulophyllum*, *Campophyllum*, *Cystiphyllum* 各種的成長率，不難推想到美國 Iowa, Illinois 與 Missouri 各省的泥盆紀海水溫度，當低於印度之 Chitral, Northern Shan States 與中國雲南，與德國似不相上下。更由 *Keriphyllum* 與 *Cystiphyllum* 的成長率亦

自 *Stereoplasma* 杯，則泡沫組織亦當出自 *Stereoplasma* 杯，然而泡沫組織往往發生於 *Stereoplasma* 塊出現以前。

二 *Cystiphyllum* 的刺狀隔壁，往往存在於不受 *Stereoplasma* 影響的部分。

三 在隔壁不到中心部的種類，其中心部亦有 *Stereoplasma* 杯的存在，而且該部分的杯部常較珊瑚體外緣的部分爲厚。

上列三點，已足證明 Wedekind 教授學說之謬誤。據著者研究現代珊瑚與化石珊瑚之結果，此種現象實不外表示季候的成長變化而已。

季候成長變化的構造

橫的組織 帶有季候成長變化的珊瑚，其泡沫組織可以看出密疎不同之兩部，其一是由小而密列的泡沫與橫板 *Tabula* 組成的部分，其二是由大而疎列之泡沫與橫板組成的部分；此二部由下而上排成極整齊的互層，自下而上，由一層向他層，泡沫形之大小的變遷通常爲漸移的，不過由密層向疎層的遷移往往亦有突變者，密層中最上部往往因受了 *Stereoplasma* 的影響而增厚構造。

縱的組織 縱的組織對於水溫之季候變化，似較橫的組織更爲敏銳，在泡沫組織密的部分，縱的組織如隔壁在橫面上是長與厚并增的。

成長率測算的結果與所得的結論

同種或同屬的現代造礁珊瑚之成長率，既然是暖處較長寒處較短，則古生代珊瑚化石上之同

大陸之赤道之分布，所用材料則只限於泥盆紀四射珊瑚。

論古生代四射珊瑚成長上的季候變化，我們必須注意兩點：其一是珊瑚化石外表的 Annulations，這種現象據著者研究的結果，完全與內部構造上的季候成長一致；其二是 R. Wedekind 教授的“*Theorie der Septalkegel*”。Wedekind 教授最近由研究 *Zonophyllum* 的個體發生而主張原來一般所目為泥盆紀的 *Cystiphyllidae*，及其近似之刺狀隔壁 (*Spinose Septa*)，乃由 *Stereoplasma* 塊羣繼續分割而成。大要是：*Zonophyllum* 最幼的部分，在珊瑚體內泡沫組織的中央部生有 *Stereoplasma* 小塊，此小塊隨着珊瑚的成長而漸擴大，變為 *Stereoplasma* 杯。此杯隨着珊瑚的成長而漸增大其口，遞減其厚，在平面上遂消滅於珊瑚體內的外緣或外壁上，新生的 *Stereoplasma* 杯常出現於舊杯消滅以前，如此層出不窮，有新舊杯底相接連與不相接連者的兩種，此杯更常以放射狀縱分為板，同一列之各杯體，縱板上下相連接者，造成板狀隔壁，其不相連接者造成刺狀隔壁。Wedekind 教授以此種現象為泥盆紀一部分四射珊瑚的特徵，並根據 *Stereoplasma* 杯羣的發達與分割的情形及刺狀隔壁連接的程度，把原來一般目為泥盆紀的 *Cystiphyllidae* 及其相近的珊瑚，分為若干屬與若干種。現代歐洲一部分古生代四射珊瑚化石專家如 Dr. E. Vollbrecht 與 C. Walther 等，多根據是說，從新整理德國泥盆紀的四射珊瑚化石之一部。據著者對 Wedekind 與 Vollbrecht 所作之圖及日本東北帝國大學教授矢部長克博士採自德國 Eifel 採來之中泥盆紀珊瑚化石觀察所得之結果，Wedekind 教授之說似是而實非，試述要點如下：

一 在 *Stereoplasma* 杯存在的部分，泡沫組織亦同時受其影響而增厚構造，如果刺狀隔壁生

古生代四射珊瑚成長上的季候變化與泥盆紀的氣候

馬廷英 著

緒論

著者自民國二十二年發見古生代四射珊瑚化石中，有若干種在其泡沫組織上帶有類似季候成長變化以後（參考文獻見英文），便專心考察古今各珊瑚是否亦有此現象，及其發達程度如何。結果發見同樣現象亦存在於古生代與中生代各紀的 *Stromatopora*、奧陶紀的 *Bryozoa*、各時代的 *Tabulate Corals* 以及化石與現代造礁四射珊瑚的組織上，並由研究現代造礁珊瑚，而證明此種現象確係因海水溫度之季候變化而生；因之又發見同一種或屬之成長率，是在寒處較短，而在暖處較長。不僅如此，著者更由比較日本、琉球與臺灣各處同一種或屬之化石與現代造礁珊瑚成長率之大小，而推出日本本島與琉球羣島各地最近地質時代之海水溫度，測定的結果是：日本本島千葉縣館山一帶，在隆起珊瑚礁的時代（*Lower Holocene*），海水溫度當略高於現在日本本島中最暖的地方——和歌山縣串本，而不能過低於現在琉球羣島中的奄美大島一帶，即在隆起珊瑚礁時代，館山一帶最寒月份之平均水溫，當比現在高出攝氏五度左右；奄美大島一帶的當時水溫，當與現在的小笠原羣島相仿，在最寒月份平均溫度似比現在高出二度上下。至於散布於琉球羣島的琉球石灰岩的沈積時代（*Lowest Pleistocene*），日本各地之海水溫度當不至高過現在太多。

本篇之工作係用同樣方法，先推究泥盆紀各國各地氣候之冷暖，然後再進而推測該時代歐亞

中國古生物誌乙種第二號

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第三冊

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中華民國二十六年五月

實業部地質調查所印行

國立北平研究院地質學研究所

(學術研究與國立中央研究院國立北京大學兩廣地質調查所湖南地質調查所合作)



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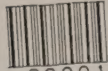
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